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THE EVOLUTION OF INTELLIGENT BEHAVIOR IN RHESUS MONKEYS*

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I. COLOR CATEGORIZING[a] WITH THE UTILIZATION OF SYMBOLIC CUES

A. Introduction

Research concerning learning and intelligence in animals has broadest application to man if the behavior patterns which are studied are homologous[2] to human intelligent performances. Basic in the intelligent behavior of man is his use of symbolic cues in adaptive responses to objects in his environment. Can such stimulus-response patterns of behavior be learned by animals below man?

This question was investigated by the writer in a series of studies with monkey subjects. Preliminary matching from sample experiments (37, 39, 40, 47) were carried out and an experimental methodology (44) was developed. The purpose of the present investigation was to determine whether monkey subjects could be trained to utilize symbolic cues in sorting responses to colored objects. The experimental procedure was planned so that a qualitative analysis could be made of the development of symbolic behavior in the subjects. Two rhesus monkeys were trained to sort red and blue objects to a symbol for red and a symbol for blue.

Matching and sorting responses appear in general tests of intelligence (23, 31, 32), in clinical tests for investigating the impairment of intelligent performances (5, 6, 13, 36), as well as in every-day human behavior. The fact that monkey subjects can be trained by means of laboratory techniques to match symbolic stimuli in color sorting performances opens a new research area for the psychological analysis of intelligent behavior. Based on such analysis the results of research concerning the neurophysiological correlates of symbolic performance in monkeys can be applied to problems of brain mechanisms and intelligence in man. In this connection a view expressed by Poliak (28) is significant. He writes:

> The brain of the lower primates is . . . in its essential features and in its finer structure a simplified replica of the human brain. . . . Certainly a systematic experimental investigation of all the chief anatomical, physiological, and psychological problems of the brain on a large scale and with a broad view, according to a prearranged plan, using primates, would give results amply compensating the labor, the time, and the expense involved.

[2]The term homologous in biology refers to similar structures having a common *phyletic origin.* A term is needed in psychology to express the concept of similar functions based on identifiable common stimulus-response factors in the behavior of different species. Homologous is here used with this psychological meaning.

The pattern for systematic investigation of cerebral function in intelligent behavior with infra-human animals has been set by Franz (4), Lashley (24, 25, 26, 27), Jacobsen (16), and Klüver (18, 19, 20). To what extent neurophysiological studies with monkeys trained to utilize symbols, can serve to supplement clinical knowledge of such organic disorders as aphasia and agnosia is a problem for future research. This problem will have special practical importance in the coming post-war era.

B. Related Studies

Previous reports of animal experiments in which matching techniques were applied have been summarized in another paper (37). Of these the outstanding investigation was the one by Kohts (22) with her chimpanzee subject, Ione. In a series of studies extending over several years, Kohts trained her subject to perform successfully in matching and sorting problems involving cues of color, pattern, and size.

A method for training monkeys in generalized matching performance—called basic matching-from-sample has been devised by Weinstein (37, 38, 39). This basic technique is utilized in the present work and in other studies by the writer (40, 41, 47). Harlow (7, 8, 9, 12) has reported a number of experiments with monkeys in which the basic matching-from-sample method was successfully applied.

Finch (3) recently carried out an experimental analysis of the delayed matching-from-sample method and the non-spatial delayed response technique of Yerkes and Nisson (50). In this study Finch raises the question, "Should Weinstein's technique (matching-from-sample with delayed reaction) be considered operationally identical with that (non-spatial delayed response) of Yerkes and Nissen?" Finch's conclusion was in the negative.

Riesen and Nissen (29) describe a new matching technique in studies of non-spatial delayed responses to colored stimuli by chimpanzees.

The use of matching and sorting problems in general tests of intelligence and in clinical studies is of special interest to the comparative psychologist. Matching problems were used in a scientific investigation, probably for the first time, by the physician Itard (15) who studied the behavior of the "Wild Boy of Aveyron" during the years 1800-1806. The boy's instruction in order "to induce him to employ the simplest mental operations" was begun with training in matching primary colors and simple geometric figures. By means of progressively more difficult problems, Itard succeeded in teaching his subject not only the use of class nouns, but adjectiveal and verbal concepts as well.

A sample matching problem with geometrical figures was devised and standardized by Kuhlman (23, Year IV, 5) in his revision of the Binet-Simon intelligence scale. This problem was adopted by Terman (32, Year IV, 2) in his 1916 revision of the same scale and also appears in both *L* and *M* forms of his 1937 revision (Form *L*, IV, 5; Form *M*, III-6, 3). In this last revision there were included a delayed matching problem (Form *L*, III, 4) and a color sorting problem (Form *M*, III-6, 5).

In the clinical field, since World War I, there have been an increasing number of studies concerning the nature of matching and sorting performances and the impairment of such behavior in human patients with brain injuries. Pioneering studies among these were those of Gelb and Goldstein (5, 6) Head (13) and Weigl (36).

One of the clinical tests devised by Gelb and Goldstein (6) was the sorting of colored stimulus objects. In this test a group of variously colored Holmgren wools was presented to the subject who was instructed to sort out all the colors which were the same or similar to a given sample; for example, a dark red. The patients would typically limit themselves to selecting only the skein which matched the sample in shade as well as in color. They seemed to be incapable of matching the sample with lighter or darker shades of the same color, even after urging by the examiner. In general, differences between stimulus objects seemed to make a much greater impression upon the patient than likenesses. Normal subjects on the other hand would readily select out all the red skeins despite differences in brightness and saturation. These two types of performance, according to Goldstein (6), illustrate the difference between concrete and abstract behavior.

In the Weigl test (36) the subject is required to alternate in the sorting of figures, first according to color and then according to form. Clinical patients were found by Weigl to be incapable of effecting the shift of set required in this task.

Head (13) studied the behavior of aphasic patients by means of his Serial Tests. Several matching problems were included. In one of these a group of six objects of daily use, such as a pencil, a key, a penny, a matchbox, a pair of scissors, and a knife were presented as choice objects. The duplicate of one of them was shown to the patient, who was then required to match it from among the group. A similar test with strips of silk of various hues was also employed. In another problem designed to test symbolic formulation the above choice objects were used but the cue stimulus was a word such as "red" printed on a card. Head reports that matching

identical stimuli was not disturbed in his patients, but hesitant behavior and errors appeared in matching a word with its corresponding object.

C. Subjects and Experimental Methods

1. *Subjects*

Two rhesus monkeys were used as subjects in this experiment. They were a large mature male monkey, *Corry*, and a mature female monkey, *Zo*. Corry was approximately five years old and Zo about three years at the beginning of this experiment. The animals were mates and were housed together. Their living quarters consisted of a hutch to which was attached an outdoor cage so that they could pass in and out at will.

The subjects were conditioned to behave coöperatively by a taming method, described later. When the training in problem solving was begun, both subjects had learned to respond to commands from the experimenter and readily coöperated in the laboratory procedures.

Corry was trained in several problems previous to the present experiment. These were a study in visual acuity (45, 46), the matching-from-sample study (37), and two problems based on the matching-from-sample technique (40, 47). Also in a preliminary unpublished study Corry was trained to successful performance in one trial discrimination and in one trial discrimination reversal problems. Corry was a highly stable subject and an efficient worker in the problem situation.

Zo had no previous training in problem solving. Although this subject would always respond to the problem situation she was not at all as stable as Corry. During the early part of training her responses to the stimulus objects were hesitant and she handled them gingerly. Later responses became excessively violent. She would push the stimulus objects across the tray and frequently throw them to the floor. Zo's agitated behavior probably resulted in part from mistreatment at the hands of the dominant monkey, Corry. Her instability seemed to have been aggravated after parturition which occurred shortly after training was begun. The infant monkey constantly clinging to its mother interfered with his subject's responses to the problem situation. It was often necessary to interrupt the training session in order to reduce agitated behavior.

2. *Apparatus*

The optimal stimulus apparatus (44) was employed in training the subjects. Three dimensional stimulus objects were placed over food wells on a

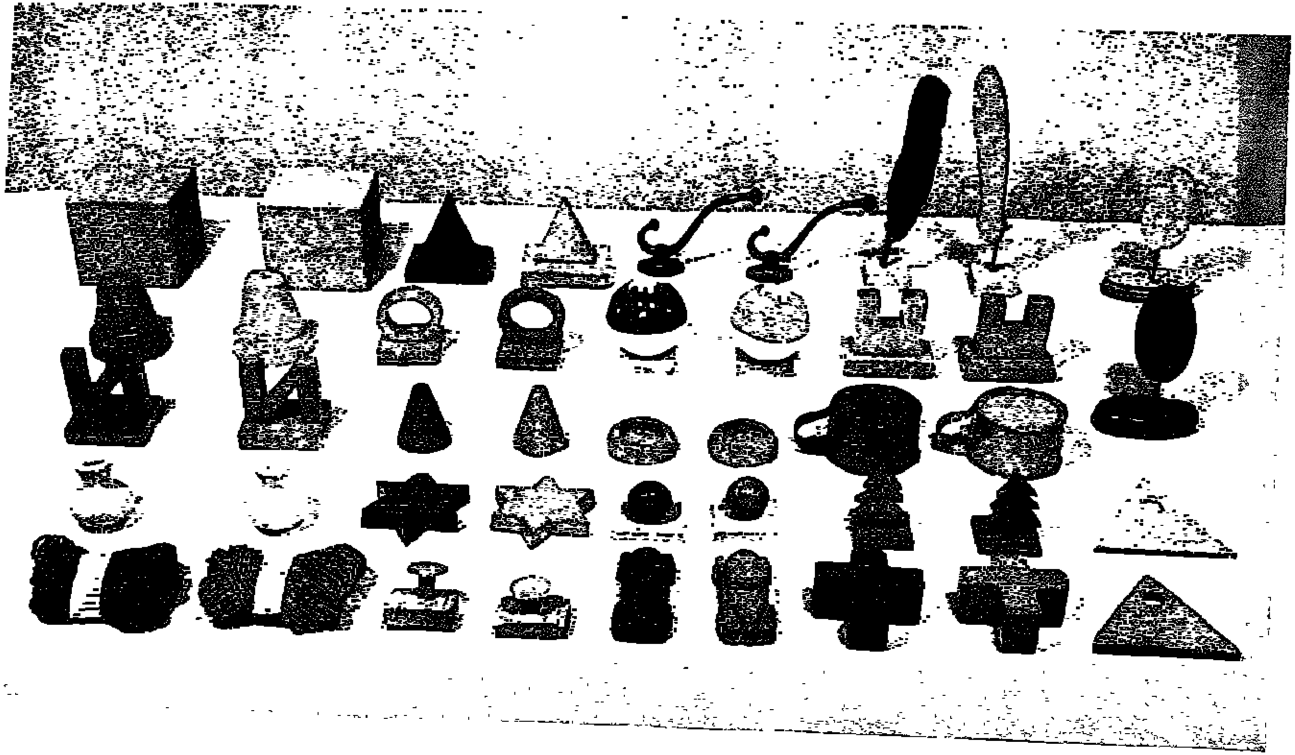

FIGURE 1

A REPRESENTATIVE GROUP OF STEREOMETRIC CHOICE OBJECTS SHOWING RANGE OF SIZE, PATTERN, BRIGHTNESS, AND SATURATION

The red triangle and blue ellipse were used as a symbol for red and a symbol for blue respectively. The uncolored triangle and ellipse functioned as color symbols in advanced stages of training.

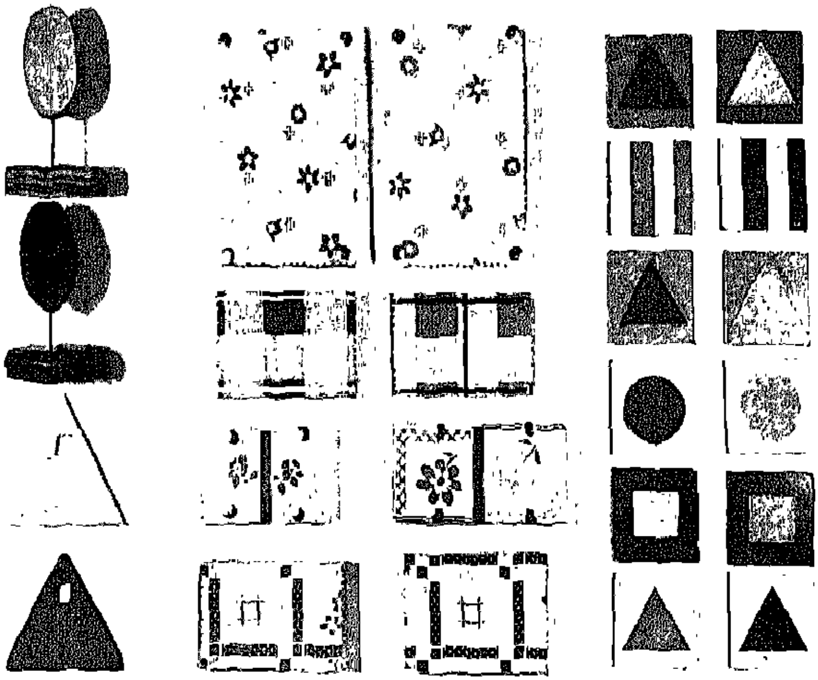

FIGURE 2

A Representative Group of Planeometric Red and Blue Choice Objects
The color symbols are shown on extreme left.

FIGURE 3 (*top of opposite page*)

Corry Sorting Out the Blue Choice Objects on Modified Large Sized Optimal Stimulus Apparatus After Having Consulted the Colored Symbol for Blue

The subject is characteristically scanning the other choice objects while obtaining the food reward from the well beneath the object just displaced. The subject has passed over the closest choice object, a red circle on a yellow background. In later stages of the experiment the uncolored symbols were used.

FIGURE 4
A Basic Matching-From-Sample Problem with the Optimal Stimulus Apparatus
(Shown from position of the subject.)

the sample and the corresponding choice object. The screen was then raised and the tray presented to the subject. In the course of the basic matching-from-sample training the food under the sample was discontinued, thus making consultation of the sample an unrewarded response.

A serial training procedure (44) was employed in which related problems were presented in a sequence from the simple to the complex. Training was begun with a matching situation in which there were but two choice-objects. There followed a series of steps in which the matching stimulus-response pattern was progressively modified by the introduction of new stimulus variables.

The training in color categorizing behavior was a further development of the *basic-matching-from-sample performance. The successive stages of training* in color sorting were planned to functionally transform one specific sample object into a symbol for red and another into a symbol for blue. The sample or cue-stimulus to represent red was an equilateral wooden triangle painted red. The sample or cue-stimulus to represent blue was an eliptical wooden figure vertically mounted on a base, painted blue. The subjects were trained to sort out the red objects from a mixed group of blue and red choice objects when the triangle was presented and to sort out the blue objects when the elipse was presented. Sorting problems are presented in Figures 3 and 5.

In the final stages of the training the cue-stimuli were uncolored, as shown in Figure 5. Therefore they bore no differential resemblance to the red and blue objects which they represented.

Each new stage was introduced when the subject reached a predetermined criterion of performance in the previous stage. Following training, the subjects were tested for generalization with red and blue choice objects which they had not previously seen.

Training sessions were given seven days a week. In rare exceptions one day was omitted. The number of training trials in each session ranged from 10 to 30, depending upon the problem.

Since the specific details of procedure can be more meanfully presented along with the corresponding data, they will be described in the following section on results.

4. *Controls for Secondary Cues*

It has already been mentioned that an opaque screen separated the experimenter from the subject while the stimulus objects and the food reward were placed into position. The experimenter was visible to the subject, however, during responses. Tests for possible secondary cues from the

experimenter were run periodically. In the control trial series the experimenter was never visible to the subject. In this control procedure the problem situation was set up and the tray pushed forward against the opaque screen in front of the experimental cage. A one-way screen was then lowered between the tray and the experimenter. Then the forward opaque screen was raised, thus presenting the problem to the subject with the experimenter out of the visual field. In these control tests there was no decrement in the performance of the subjects.

The development of responses to secondary cues tended to be forestalled by the tuitional procedures used in training the subjects. It is well known that the probability of simulating correct responses by means of cues unknown to the experimenter, is a function of problem difficulty. The experimentally planned cues, offered by tuition, reduced the difficulty of the problem and also enabled the experimenter to observe with greater certainty the cues to which the subject was responding.

The behavior of the subjects was carefully observed during experimentation for possible secondary cues. The active self-stimulation with the sample object, the examining behavior towards choice objects, the interruption of choices to re-consult the sample[8] all served to indicate that secondary cues were inoperative.

D. Results

1. *Basic Matching-From-Sample*

a. Stage 1. Matching with two choice-objects. Training was begun with matching one of two choice-objects with its replica, the sample. The two samples were alternated in a predetermined irregular sequence.

The subjects here learned to initiate each trial by contacting the sample and then to make a differential response to the adjacent choice-objects on the basis of similarity and difference. The successful matching performance involved a ready exchange of selective and avoidance responses to each of the two choice-objects, since their positive and negative values were randomly reversed from trial to trial.

The same set of stimulus-objects were used throughout this stage of training. The criterion of mastery was set at 23 correct choices in 25 consecutive trials. The number of training trials required by each subject to attain this criterion and the number of correct responses in the last 25 trials are presented in Table 1.

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[8]These terms are descriptive of stimulus response patterns which have been recorded in motion picture films (38, 41, 43).

TABLE 1

SUMMARY OF THE RESULTS OF TRAINING IN MATCHING WITH FIRST TWO CHOICE-OBJECTS

Subjects	Number of training trials	Correct choices in last 25 trials
Corry	1,199	24
Zo	950	23

b. Stage 2. Matching with a new set of stimulus-objects. Training was given in transferring the matching performance to a new pair of sample-objects and their choice-object replicas. The results are summarized in Table 2.

TABLE 2

SUMMARY OF THE RESULTS OF TRAINING IN MATCHING WITH SECOND TWO CHOICE-OBJECTS

Subjects	Number of training trials	Correct choices in first 25 trials	Correct choices in last 25 trials
Corry	137	16	23
Zo	75	21	23

c. Stage 3. Generalization of matching performance. The subjects were trained with the pairs of choice-objects changed in successive trials. The pairs were drawn from 24 different choice-objects, so that in each series of 24 trials each object served as a positive stimulus once and as a negative stimulus once. When a score of 22 correct choices in 24 consecutive trials was attained, the subjects were tested for the generalization of the matching performance with 24 entirely new choice-objects.

Following the terminology used by Köhler (21) and by Klüver (18), the test trials with the new objects are designated as critical trials. The data in Table 3 show that the subjects successfully generalized the matching

TABLE 3

SUMMARY OF THE RESULTS OF TRAINING IN GENERALIZED MATCHING WITH 24 DIFFERENT CHOICE-OBJECTS PRESENTED IN PAIRS

Subjects	Number of training trials	Correct choices in first 24 trials	Correct choices in last 24 critical trials
Corry	74	20	22
Zo	100	18	23

performance immediately upon the presentation of a series of unfamiliar choice-objects.

d. Stage 4. Generalization of matching performance with four choice-objects. The number of choice-objects presented in each trial was increased

to four as shown in Figure 4. The increased number of objects and the decreased distance between them introduces the additional task of differentiating a complex perceptual field. The difficulty of this task was indicated by the decrement in correct responses and by the hesitating[4] uncertain behavior with the new set-up.

Initial training was given with four familiar choice-objects. Next, groups of four choice-objects were rotated from among 20 different objects, some of which were new. After the subjects reached the criterion of 22 correct responses in 24 consecutive trials, a series of 24 critical trials were given with 24 new choice objects. The results of this stage are given in Table 4.

TABLE 4
SUMMARY OF THE RESULTS OF TRAINING IN GENERALIZED MATCHING WITH 24 DIFFERENT CHOICE-OBJECTS PRESENTED FOUR AT A TIME

Subjects	Number of training trials	Correct choices in first 24 trials	Correct choices in 24 critical trials
Corry	349	17	23
Zo	632	15	23

2. *Color Categorizing*

The training in color categorizing was carried out as a modification of the mastered basic matching-from-sample performance. The procedure was directed towards training the subjects to sort a mixed group of red and blue objects according to color, in response to symbolic cues.

The analysis of the psychological factors involved in the development of color categorizing performance may be made in terms of the degree of stimulus specificity to which correct responses tend to be limited. Thus symbolic performance may be regarded as the product of behavioral evolution during which the organism established a cue-constancy of a given stimulus, i.e., its cue value remains effective despite major changes in the stimulus context. Accordingly, the training sequence was planned to introduce, serially, variations of specific aspects of the stimulus situation. The variables were pattern, size, number, brightness, saturation, dimension, background, and configuration of the choice-objects and the locus of the cue-object in the stimulus field. A problem situation which includes all these variables is shown in Figure 3.

a. Stage 1. Color matching with variations in pattern and size of choice-objects. Training in the color categorizing problem was begun with choice-

[4]The record which was taken of reaction times indicates longer delays in responses by both subjects whenever new objects were introduced. Reaction times increased from approximately one second to 2-7 seconds and sometimes as high as 60 seconds.

objects which were exact replicas of the cue-objects—red triangle and blue elipse. Since this is a simple matching problem both subjects solved it in the first 25 trials as shown in Table 5.

TABLE 5

SUMMARY OF THE RESULTS OF TRAINING IN COLOR MATCHING WITH A SERIES OF RED AND BLUE CHOICE-OBJECTS VARIED IN PATTERN AND SIZE

	Number of training trials		Correct choices in the first 25 trials		Correct choices in the last 25 trials	
	Corry	Zo	Corry	Zo	Corry	Zo
Set 1	25	25	24	24	—	—
Set 2	25	25	23	23	—	—
Set 3	25	275	20	14	—	23
Set 4	50	125	18	15	24	20
Set 5	75	100	17	13	22	20
Set 6	75	125	13	16	20	20
Set 7	25	340	21	13	—	20
Total	300	1,015				

Choice objects were next introduced which differed slightly in pattern and size from the cue-objects. They were a red isoceles triangle about half the area of the sample triangle and a blue circle (mounted on a base) which was smaller in area than the eliptical sample.

New choice-objects were successively introduced in the course of this stage. The objects varied markedly in pattern and size but retained the same red or blue hue. The criterion of learning was lowered to 20 correct choices in 25 successive trials because fewer training trials with a given set of choice objects would make the transition to a new set less difficult.

In this color matching problem a set-up with only two choice-objects makes possible correct responses to an extraneous non-matching cue. This cue is the maximal homogeneous color area of the stimulus objects on the tray. For example, if the red sample with a red and blue choice-object are considered, it will be seen that the total red surface on the tray is greater than the total blue surface. In order to obviate this secondary cue, three choice-object set-ups were introduced into the trial series. For example, the red sample with one red choice-object and two blue choice-objects provides equal areas of the two colors. The trials with two and three choice-objects were alternated in a predetermined irregular sequence.

The numbers of training trials which the subjects required to attain to the criterion with each set of choice-objects are given in the first column of Table 5. In the next column are the numbers of correct choices in the first 25 trials with each set. Zo shows a consistent decrement of per-

formance in the initial trials with each new set of choice-objects. Corry's transfers are good with one exception. The number of correct choices for each subject in the critical 25 trials are given in the last column.

Stage 2. Generalization of color matching performance with pattern and size variations. In each training session of the previous stage there were but two different choice-objects used. Now the choice-objects were rotated from among a set of 25 objects. Each object was employed only once as a positive choice-object in a training session. Thus in each session the subjects were trained in color-matching problems with a broad variety of choice-objects.

Successful color-matching within a limited group of choice-objects by no means insures immediate transfer to a new and extensive set of stimuli. This is indicated in Table 6 by the sharp decrement of performance with

TABLE 6
SUMMARY OF THE RESULTS OF TRAINING IN GENERALIZATION OF COLOR MATCHING WITH CHOICE-OBJECTS VARIED IN PATTERN AND SIZE

	Number of training trials		Correct choices in the first 25 trials		Correct choices in the last 25 trials	
	Corry	Zo	Corry	Zo	Corry	Zo
First set of 25 objects	220	1,440	15	12	21	20
Second set of 25 objects Critical Trials	50	100	18	19	22	22

the first set of 25 choice-objects. However, after training with this first set there was successful transfer to the second set of 25 diversely patterned choice-objects. Both subjects made a score reliably better than chance during the first 25 trials with these new objects.

During this stage, Zo the female monkey, showed an improvement in her efficiency of responses. Up to this time Zo would begin each trial orientated towards the choice-objects, (presumably towards the locus of the reward) giving the sample only a hasty look or touch. Commencing a trial with an orientation toward the unrewarded cue-object, since it is in a direction away from the locus of the food can be regarded as a form of "*umweg*" behavior. Previous lack of this type of response in Zo was undoubtedly one factor in her slow progress. In this stage Zo acquired the habit of initiating each trial with a vigorous and even frantic manipulation of the sample. This swinging from one extreme of behavior to the other was characteristic of the excitability of this subject throughout the experiment. The performance of the other subject, Corry, was in the main calm and

deliberate. Tense behavior in this subject was manifested in the action of gnawing the cue-object before making a choice. Corry acquired the habit of active self-stimulation with the sample during the basic matching-from-sample training.

With the completion of this stage the subjects' color matching performances were generalized, within experimental limits, to three-dimensional choice-objects of any size and pattern.

c. Stage 3. Color matching with variations in the number of correct choice-objects—color sorting. A set of 26 stereometric objects, 13 red and 13 blue, in diverse patterns and sizes was employed in this stage. From this set groups of four choice-objects were presented in successive trials. The objects were taken from the set in rotation so that each object was used as both positive and negative. In the previous problem there was but one correct choice-object in each presentation. Now the number of correct choice-objects was varied from zero to four, that is, zero, one, two, three, or all of the choice-objects were indicated by the sample in successive trials in an irregular sequence. After sorting out the objects indicated by the sample, the subject was required to refrain from displacing the remaining choice-objects during a 30-second period, after which the trial was terminated.[5] With a zero-correct choice-object set-up the subject was required to refrain from displacing any choice-object for a 30-second period after contacting the sample. A reward was handed to the subject for an appropriate inhibition of response.

During early training both subjects showed a tendency to continue displacing objects after the correct ones had been chosen, or to displace choice-objects in the zero-correct trials. They showed a willingness as it were to put a red object into the blue category for the sake of a possible piece of banana. With further training the subjects learned to refrain from displacing incorrect objects after correct responses. The data of this stage are presented in Table 7.

TABLE 7

SUMMARY OF THE RESULTS OF TRAINING IN COLOR CATEGORIZING WITH THE NUMBER OF CORRECT CHOICE-OBJECTS VARIED IN SUCCESSIVE TRIALS

Subjects	Number of training trials	Correct choices in first 25 trials	Correct choices in last 25 trials
Corry	545	6	21
Zo	895	8	22

[5]The subject *Corry* gave a behavioral indication of terminating his sorting response. He would throw the symbol onto the tray with an air of finality and often turn away.

d. Stage 4. Color sorting with variations of brightness and saturation. A set of 12 red and 12 blue choice-objects were used, each hue in two values. The objects were painted so that there were six brighter and six darker than the red cue-stimulus, and similarly six brighter and darker blue choice-objects. The variations of the previous stages were retained. The decrement in performance during the first 25 trials as well as the initial hesitating behavior of the subjects indicate a degree of restriction to brightness and saturation values identical to those of the cue-stimulus. The results are summarized in Table 8.

TABLE 8

SUMMARY OF THE RESULTS OF TRAINING IN COLOR CATEGORIZING WITH VARIED BRIGHTNESS AND SATURATION OF THE RED AND BLUE CHOICE-OBJECTS

Subjects	Number of training trials	Correct choices in first 25 trials	Correct choices in last 25 trials
Corry	175	15	20
Zo	180	10	21

e. Stage 5. Color sorting with two-dimensional stimuli. The choice-objects were three-inch squares of masonite. The smooth surface of these objects were painted the same shades of red and blue as the objects in Stage 4. The red and blue stimuli therefore now appeared in one plane. The data are given in Table 9.

TABLE 9

SUMMARY OF THE RESULTS OF TRAINING IN COLOR CATEGORIZING WITH TWO-DIMENSIONAL STIMULI AS CHOICE-OBJECTS

Subjects	Number of training trials	Correct choices in first 25 trials	Correct choices in last 25 trials
Corry	210	4	20
Zo	685	15	20

f. Stage 6. Color sorting with varied backgrounds. Diversity of background was now added to the previous variables. The choice-objects were three-inch squares of masonite on which geometrical blue and red figures were inscribed on the background colors, white, yellow, black, green, or gray. A set of 28 objects were used from which the four choice-objects were drawn in each trial. During training in the problem Zo showed extremely agitated and frustrated behavior. Responses were so disorganized that training was discontinued with this subject. Corry's gnawing activity on the samples increased. He ruined several sets of cue-stimuli during this stage of training. The data for this subject is given in Table 10.

g. Stage 7. Color sorting with variations of configurations of choice-

TABLE 10

SUMMARY OF THE RESULTS OF TRAINING IN COLOR CATEGORIZING WITH VARIED BACKGROUNDS ON THE TWO-DIMENSIONAL CHOICE-OBJECTS

Subject	Number of training trials	Correct choices in first 25 trials	Correct choices in last 25 trials
Corry	555	6	20

objects and locus of sample. Instead of presenting the choice-objects along a straight line, they were now arranged in random configurations on the larger 24" x 24" tray. The number of choice-objects in each trial were gradually increased from four to eight. The cue-stimulus was no longer placed in the sample-object area. It was presented in various positions on the tray or handed to the subject. That the locus of the cue-stimulus was highly specific in Zo's matching and sorting performance was indicated by the fact that she would cease to make choices when she would accidently displace the sample from its accustomed position. The data concerning Corry's performance in this stage are given in Table 11.

TABLE 11

SUMMARY OF THE RESULTS OF TRAINING IN COLOR CATEGORIZING WITH VARIED CONFIGURATIONS OF THE CHOICE-OBJECTS AND VARIED LOCI OF THE CUE-STIMULUS

Subject	Number of training trials	Correct choices in first 25 trials	Correct choices in last 25 trials
Corry	280	11	21

h. Stage 8. Generalized color sorting with choice-objects seen for the first time. Retaining all the variables previously described, a new set of 28 red and blue objects were employed, some of which were made at the laboratory and others purchased at the five-and-ten-cent stores. Examples of the latter were celluloid spheres, flower pots, glass ash trays, and skeins of wool. The new objects had the advantage of offering a broad diversity of textures of red and blue. These objects which differed markedly from the previously used laboratory-built objects, seemed to have a "shock" effect upon the subject. During the first two trials there was prolonged handling and biting of the sample, but complete refusal to touch any of the choice-objects. In the next few trials the subject made hesitant choices in response to urging from the experimenter. The data in Table 12 shows that the sorting of new objects was a difficult task for the subject.

In order to test Corry's responses to an extensive series of choice-objects, 104 objects from among those previously used were presented in the course of 50 trials. The objects were presented in groups of four in a trial order

TABLE 12

SUMMARY OF THE RESULTS OF TRAINING IN GENERALIZING COLOR CATEGORIZING PERFORMANCE IN SITUATIONS WHICH INCLUDED ALL THE PREVIOUS VARIABLES

Subject	Number of training trials	Correct choices in first 25 trials	Correct choices in last 25 trials
Corry	294	14	21

unfamiliar to the subject. Since a familiar trial series can be utilized by monkeys as a cue for correct responses, this test served as a control for this extraneous cue. Corry's score was 44 correct choices and six errors in 50 consecutive trials.

Generalization performance was further tested with another new set of 52 objects, including all the previous variables. From this set the choice-objects were again rotated in groups of four. The subject's behavior did not appear as disturbed with these unfamiliar objects as with the previous new set. There was one pair of new objects however which did elicit overt fear responses. These were a large blue and a large red feather. Corry's score was 36 correct choices and 16 errors in 52 consecutive trials.

i. Stage 9. Color categorizing performance with uncolored cue-objects. In the course of the previous stages all resemblances between the cue-objects and the class of objects which they represented were removed with the exception of hue. Up to this point in the training the triangular cue-object was painted red and the eliptical cue-object was painted blue. Training was now begun with an uncolored triangle and an uncolored elipse as cue-objects. With this change in the stimulus situation there was no resemblance whatsoever between the symbols and the objects which each represented. During the training in this stage all the previous sets of objects were used. From these the choice-objects were rotated in groups of four. All the variables described above were retained. For the two dimensional choice-objects blue and red cloths tacked on blocks were employed. Corry is shown utilizing the uncolored symbol in Figure 5. The data for this stage is given in Table 13.

In order to test for generalization of color categorizing performance with

TABLE 13

SUMMARY OF THE RESULTS OF TRAINING IN UTILIZING UNCOLORED CUE-STIMULI IN COLOR CATEGORIZING PERFORMANCE

Subject	Number of training trials	Correct choices in first 25 trials	Correct choices in last 25 trials
Corry	1,248	9	21

uncolored symbols an altogether new set of 44 choice-objects were now introduced. A one-way screen was also used in this test to control for secondary cues from the experimenter. Under these conditions the subject made 36 correct choices and 14 errors in 50 consecutive trials.

j. Stage 10. Training in symbol selection. In the language development of children correct application of a word to its corresponding object is acquired subsequent to learning the appropriate selection of an object in response to the word. For example, in response to the spoken stimulus "doll" the child will select that object from among her toys earlier than she can respond with the word when the doll is presented. In the previous stages of this experiment, in response to the symbolic stimulus, triangle, the subject selected the red objects; and in response to the symbolic stimulus, elipse, he selected the blue objects. Corry was now trained in the converse performance of selecting the triangle in response to a red object and selecting the elipse in response to a blue object.

The uncolored symbols were presented on the large tray in various positions along with a red or a blue object. The colors were alternated in a random sequence. The subject was required to consult the colored object and then displace the corresponding symbol in order to obtain a food reward.

In the initial presentations the subject seemed to "miss the point" of this new problem. In a hesitating manner he would displace the colored stimulus object and seek for food beneath it—that is, he treated this situation as he did the stimulus situations of the previous stages. The subject also displaced the symbols, apparently in a random fashion. In the first 10 trials there were five correct choices and five errors. Within the first 25 trials self-correction responses appeared in which the subject began a trial by tentatively touching the incorrect symbol and then changed over to displacing the correct symbol. Also the subject began to show comparing head movements between the colored object and the symbol. In the latter part of the training the experimenter was hidden by a one-way screen during choices. The criterial score was set at 21 correct choices in 25 successive trials. The data are presented in Table 14.[6]

[6]*Corry* was retested 21 months after this experiment was terminated. He completed 25 trials of the basic matching-from-sample problem without a single error. In 25 trials of the color categorizing problem no trial was correctly completed. Retraining was not attempted.

I take this opportunity to thank Dr. Roland K. Meyer of the Biology Department at the University of Wisconsin for the care he has given Corry in his laboratory during the past two years.

TABLE 14

SUMMARY OF THE RESULTS OF TRAINING IN SELECTING THE SYMBOL CORRESPONDING TO A PRESENTED COLORED OBJECT

Subject	Number of training trials	Correct choices in first 25 trials	Correct choices in last 25 trials
Corry	70	16	21

E. DISCUSSION

The terms symbol and symbolic behavior have been used with widely differing meanings in the psychological literature. The criteria for symbolic behavior as the term is applied in this study are formulated from a consideration of human responses to word stimuli.

Such stimulus-response patterns, in simplified forms, appear in clinical and in general tests of intelligence. Examples are the two clinical tests devised by Head (13), the Naming and Recognition of common objects and the Naming and Recognition of colors. In these tests the subject is required to choose objects, one at a time from a group of choice-objects, in response to printed names successively presented on cards. The choice-objects in the first test are six articles of common use such as, a pencil, a key, a penny, a matchbox, a pair of scissors, and a knife. Eight colored strips of silk are employed in the second test.

In the successful performance in these tests the subject utilizes a cue-stimulus which has a representative function in the selective response to the corresponding object. The choice-object employed have familiar characteristics, but the particular pencil, key, etc., presented in the test was not previously seen by the subject. Since these articles may differ in certain aspects from any which he has seen previously, selective responses are made to them as members of a class. In the course of the tests, as successive cue-stimuli are presented, there occurs a ready exchange of positive responses and inhibition of positive responses between alternate choice-objects. The printed word, or cue-stimulus, is a symbol whose meaning, acquired by previous training, enables the subject to make equivalent responses to different objects having a common property.

From the above analysis, the following tentative criteria for symbolic behavior are proposed:

1. The organism utilizes cue-stimuli whose representative rôles were developed in the course of previous training.

2. The cue-stimulus elicits selective responses to diverse objects having a common property.

3. The organism utilizes a cue-stimulus in making selective responses to objects seen for the first time, but possessing a familiar common property, i.e., responses are made to objects as members of a class.

4. The cue-stimulus is non-identical with the objects which it represents.

5. The organism readily shifts positive responses and inhibition of positive responses between alternate objects as the cue-stimuli are exchanged.

These criteria for symbolic behavior are satisfied by the performances of the subjects in Stage 2 of the training in color categorizing. The generalization test terminating this stage shows that the subjects had learned to select any red object from a group of red and blue choice-objects seen for the first time—in response to the cue-stimulus, red triangle and to select any blue object from the group in response to the cue-stimulus, blue elipse. The choice-objects in each of the two colors differed widely in pattern and size. The consistent responses to the diverse red and the diverse blue choice-objects indicate responses to the objects as members of two alternate classes, each class having the common property of a given color. The red triangle and the blue elipse served as symbols for red objects and blue objects, respectively.

A learned response of an organism can be regarded as an evolutionary event which is both the culmination of previous development and the basis for further development of adaptive behavior. The symbolic performance in Stage 2 of the color categorizing training is such an event. The problem solving performances in the preceding and subsequent stages constitute a behavioral continuum in which the subjects learned to utilize cue-stimuli in increasingly more complex situations.

The following analysis of the development of symbolic behavior in the subjects traces the changes of stimulus-response patterns in the successive stages of the experiment. For this analysis it is clarifying to consider the distinction between sign and symbol as advanced by Dewey (1, Ch. III).

Both sign and symbol, according to Dewey's formulation, are stimuli which have representative value to the organism. The representative effectiveness of a sign, however, is closely bound to a specific stimulus context. The representative effectiveness of a symbol, on the other hand, is relatively free of the stimulus context—it remains stable despite large variations in the stimulus conditions. For example, the *object* cloud and the *word* rain are cue-stimuli both of which represent a downpour, but the former functions as a sign and the latter as a symbol.

The training procedure in the present study was planned to functionally transform two cue-stimuli from signs into symbols by extending the stimulus conditions in which the subjects could utilize them. During the early train-

ing in the basic matching-from-sample problem the subjects could utilize the sample as a cue-stimulus only if it was reinforced with a food reward. This food limitation on the representative value of the sample was removed with additional training. Responses to the sample as a cue-stimulus previously *food-bound,* now became *food-free.*

In the first step of the training in color matching (as in the basic matching-from-sample problem) a necessary condition for correct responses was exact similarity of the cue-stimulus to one of the choice-objects. Successful matching performance here was limited to a specific stimulus context. The subjects matched correctly only in a situation in which the pattern and size of the correct choice-object was identical with those of the cue-stimulus, only with identity of brightness and saturation, only with one correct choice-object, only with three dimensional choice-objects, only with the choice-objects in one specific configuration—on a straight line, and only with the cue-stimulus in a specific locus with reference to the choice-objects. In the subsequent stages of the experiment the subjects' responses were freed from these restrictions.

In the course of the training steps in Stages 1 and 2 the subjects learned to select a red choice-object of any size or pattern when the red triangle was presented as the cue-stimulus and to select a blue object of any size or pattern when the blue elipse was presented as the cue-stimulus. *Size-bound* and *pattern-bound* responses therefore became *size-free* and *pattern-free.*

Matching responses in which the subject consistently selects one, and only one, of the presented choice-objects involves the stereotypy of single choices. Matching performance tends to become stabilized as the selection of but one choice-object, i.e., responses are *number-bound.* In Stage 3 the subjects were trained to select the one, the two, the three, or the four of the choice-objects which matched the cue-stimulus in color. They also were trained to refrain from making any choice when none of the choice-objects matched the cue-stimulus. The subjects learned to make ready shifts from trial to trial in the number of choice-objects selected. Thus responses became *number-free.*

In this stage selective responses were made to several like colored objects simultaneously, i.e., during any given trial. Also the subjects learned to refrain from making further choices after the indicated objects had been selected. Therefore color categorizing performance was initiated in this stage.

Color categorizing performance was extended in Stage 4 so that it was independent of any specific brightness and saturation of the choice-objects.

As a result of the training in this stage, *brightness-bound* and *saturation-bound* responses became *brightness-free* and *saturation-free*. Pertinent to this phase of training are the clinical reports of the Gelb-Goldstein Color Sorting Test (6, pp. 58-80). Impaired color sorting performance which is restricted to the matching of colors having identical brightness and saturation are reported in subjects with organic and functional brain diseases. Such restricted performance in contrast to the normal sorting of colors despite differences in brightness and saturation, according to the analysis of Gelb and Goldstein, illustrate the difference between concrete and abstract behavior.

The subjects learned to sort two-dimensional red and blue choice-objects in Stage 5. *Dimension-bound* sorting performance, i.e., restricted to three-dimensional choice-objects, here became *dimension-free*.

In Stage 6 diversity of backgrounds was added to the previous variables in the color-categorizing problem. Zo was unable to adjust here performance to this new variable despite her agitated efforts. Her responses remained *background-bound*. Corry developed *background-free* responses in this stage.

Until Stage 7 the stimulus objects were presented in a straight line configuration with the cue-stimulus in a specific locus on the subject's right. Color sorting responses limited to this regular array of objects in the stimulus field are *configuration-bound* and *locus-bound*. The subject, Corry, was now trained in color-categorizing with four to eight choice-objects distributed in randomly varied configurations over the entire surface of the 24" x 24" stimulus tray. The cue-stimulus was presented in randomly varied loci on the tray, or it was handed to the subject. With the arrangement of choice-objects one behind the other, the tendency to select proximal objects needed to be overcome. Sorting performance now required that distant positive objects be selected, and close negative objects be avoided. In this stage responses to the choice-objects became *configuration-free*, and responses to the cue-objects as symbols became *locus-free*.

In the basic matching-from-sample problem exact identity between the cue-stimulus and the corresponding choice-object was a necessary condition for solution. During the training in the color categorizing problem, similarity between cue-stimulus and corresponding choice-objects was progressively diminished. The forms triangle and elipse came to function as cues or symbols for red objects and blue objects respectively. Up through Stage 8 the red and blue color on the cue-objects remained as supplementary cues

to the triangular and eliptical forms. In Stage 9 the subject Corry was trained to utilize the uncolored forms themselves as symbols.

It is characteristic of word-cues that they function despite the absence of any differential resemblance to the objects which they represent. For example in Head's color selection test described above, the word-cues *RED* and *BLUE* printed on cards had no physical equivalence to the correspondingly colored strips of silk. With the removal of color similarity between the triangle and red objects and the elipse and blue objects, the rôle of these symbols became homologous to word stimuli.

The utilization of the symbolic cues in the sorting of colored objects into two classes is interpreted as an integration of behavior on the conceptual level. The color categorizing performances indicates that in the course of training the subjects developed concept behavior towards red and blue objects.

In the final stage of the training the subject, Corry, learned to select the appropriate symbol (uncolored) when the triangle and elipse were presented along with a red or a blue object. Since this stimulus-response pattern is the converse of selecting a colored object in response to a symbolic cue it is termed *converse symbolic behavior*. The transition from color categorizing performance to converse symbolic behavior was made in very few trials. It appears therefore that the two stimulus-response patterns have a close genetic relationship.

The acquirement of symbolic behavior as observed in the subjects appears as an evolutionary process in which the organism learns to utilize representative cues in a series of related choice situations involving progressively less specificity of stimulus conditions. Thus the organism establishes a *cue-constancy* of a surrogate object, i.e., the object continues to be utilized as a cue for the selection of other objects despite appreciable changes in the stimulus context. Symbolic performance, because of its relative freedom from specific stimulus conditions, serves more effectively as the basis for the solution of new problems than do other types of adaptive behavior. In a complex and ever changing universe the highly adaptive value of symbolic behavior is obvious.

F. Future Lines of Research

The experimental analysis of intelligent behavior into primary stimulus-response factors is a broad research task of psychology. The problem is important not only for systematic psychology but it is also fundamental in the neurophysiological study of intelligent behavior. The neurophysiologi-

cal view is expressed by Poliak in his extensive study of the afferent fibre systems of the primate brain. He writes (28, pp. 216-217):

> At present the difficulties in solving mental-material relations appear, on the whole, to reside less in the sphere of morphology than in the definition of localizable cortical processes. Psychological methods of investigating the manifestations of mental phenomena are comparatively crude and clinical methods are even more so, dealing as they do, mostly with composite symbols to which can hardly be assigned their adequate morpho-dynamic parallels or correlates in restricted, narrow localities and definite structures.

Future uses of the basic matching-from-sample method for experimental analyses of types of intelligent behavior are here indicated. Comparative studies of the development of symbolic performances in preschool children and in monkeys are to be carried out. Commencing with the matching of identical objects and successively introducing appropriate stimulus variables, a study of the formation of color, form, and number concepts can be made. Cue-objects in such studies would be developed into visual symbols which would elicit responses to specific colors, forms, or numbers. Transitions can then be made to corresponding auditory symbols. Preliminary observations with Corry indicated that he could make appropriate sorting responses to the spoken words red and blue, after he had mastered the visual symbols.

Behavioral analyses of symbolic performances having been made the question then to be investigated is, what are the brain mechanisms corresponding to these functions. Using the trained monkey subjects, a program of brain extirpation of circumscribed cortical areas can be instituted in order to study post-operative impairment of symbolic behavior.

A parallel training and testing program with brain injured patients would enhance the value of both the psychological analyses and brain localization studies.

G. Summary

1. A new experimental method is described for studying learning and intelligence in infra-human primates. Monkey subjects were trained, by serial modifications of basic matching-from-sample performance, to utilize symbolic cues in sorting red and blue objects, i.e., color categorizing.

2. The matching and sorting performances of the monkey subjects are homologous to matching and sorting responses required in human tests of intelligence, e.g., the Stanford-Binet scale and the clinical tests devised by Gelb and Goldstein and by Head.

3. An experimental analysis was made of the development of the sym-

bolic performances in the subjects. Acquirement of symbolic behavior appears as an evolutionary process in which the organism learns to utilize representative cues with progressively less specificity of the stimulus context. Bound responses gradually become free of specific stimulus conditions. Thus the organism establishes a cue-constancy of a surrogate object in diverse choice situations having a common aspect.

4. A tentative set of criteria for symbolic behavior is derived from a consideration of human stimulus-response patterns involving word cues.

5. Future lines of research are indicated for comparative studies of intelligent performances with infra-human primates, children, and brain injured patients as subjects.

6. Neurophysiological research employing the psychological methods herein described is envisaged. Monkey subjects trained in symbolic behavior should prove valuable preparations for investigating problems of cerebral localization of intelligent performances.

II. METHODOLOGY FOR DEVELOPING INTELLIGENT BEHAVIOR IN MONKEY SUBJECTS

A. Introduction

The importance of appropriate techniques for handling and training infrahuman primates as subjects in psychological research has been pointed out by Yerkes (49), Köhler (21), Kellogg (17), and Klüver (18). Laboratory observations make it increasingly evident that the success or failure of an animal subject in solving a given problem, depends in large measure upon the techniques which the experimenter employs. A performance which seems impossible for an animal to learn with a given training procedure may be mastered with other methods more suitable to the reaction tendencies of the subject. The question of animal intelligence resolves itself into the problem of effective techniques for the alteration of existing responses. The active modification of behavior as experimental method for developing new stimulus-response patterns in the subject is a central task of animal studies concerning learning and intelligence.

A methodology for modifying adaptive behavior in monkeys was developed during the years 1938-1940 by the writer at the Primate Laboratory of the University of Wisconsin. In order to gain a closer acquaintance with the monkey's behavior and to discover suitable procedures for modifying it, many hundreds of hours were spent with monkey subjects in informal observations of their reaction tendencies towards the experimenter and towards various kinds of visual and auditory stimuli.

With the methodology developed it was shown in a series of recent experiments (37, 39, 40, 42, 47) that monkeys can be trained to solve matching and sorting problems homologous to test items in human intelligence tests. The techniques employed were:

1. *Basic matching from sample.* An experimental method in which the subject is trained in the problem of matching identical stimulus objects. Matching performance generalized to stimulus objects seen for the first time completes the problem. This technique is named basic matching-from-sample because it prepares the subject for the more complex variants of matching performance.

2. *The optimal stimulus apparatus.* An apparatus designed for arranging the stimulus field so that it is most conducive to problem solving. The apparatus consists of three dimensional stimulus objects placed over foodwells on a tray under bright illumination.

3. *Tuition.* A training procedure which provides the subject with experimental guidance in order to facilitate learning.

4. *Taming method.* A conditioning procedure planned to establish co-operative behavior in the subject in the laboratory routine and to secure a high attention level in the problem situation. Emphasis is placed upon direct measures by the experimenter himself to correct unadjusted emotional behavior in the subject.

These techniques have also been successfully applied in a series of problem solving experiments at the Wisconsin Laboratory reported by Harlow and students (7, 8, 9, 10, 12, 30, 51).

B. Basic Matching-From-Sample

Problems involving matching performance are found in many tests of general intelligence. In the Stanford-Binet intelligence scale (31), in Form *L*, IV, 5 the subject is presented with a sample geometrical figure and he is required to match it from among a group of choice figures. Form *L*, III, 4 is a delayed matching problem in which the subject is first shown a sample figure, then after a brief delay he is required to select its replica from among a group of choice figures. Matching problems appear in the Thurstone ability test (34) and in several clinical tests of intelligence, devised by Head (13), Weigl (36) and Gelb and Goldstein (6).

Since matching performances have shown high correlation with general intelligence, matching problems are especially suitable for experimental analysis of intelligent behavior. A matching-from-sample method adapted to monkey subjects has been devised by the writer (37) as a means for comparative studies. The experiment was later repeated at the Wisconsin Laboratory with a new group of animal subjects (39).[7] The method used in these experiments is called basic matching-from-sample because it is a technique for initiating the training of the subject in the more complex variants of matching performance.

The basic matching-from-sample method is designed to train the subject, by means of a series of transitional problems, to generalize the matching performance, i.e., to match a sample object with its replica in a group of four diverse choice-objects seen for the first time. The problem situation consists of a tray bearing a sample-object on the subject's right and a

[7]The repeated experiment was described by the writer in Seashore, R. H. (ed.), *Fields of Psychology*, New York, Henry Holt & Co., 1942, pp. 179-184. Subjects 50 and 51 of this experiment were trained by Doctor H. F. Harlow and Subjects 52 and 53 by Mr. A. Bollig.

group of two to four choice-objects on the left (see Figure 4). The subject is trained to first consult the sample and then select its replica from among the choice objects in order to obtain a food reward. The sample functions as the cue for the differential response to the choice-objects. The sample-object is randomly changed in successive trials so that there are frequent reversals of the positive and negative values of the choice-objects. The relative positions of the choice-objects are also varied in a predetermined random sequence. In a critical trial series, which tests for generalization, the sample and the choice-objects are rotated from a set of 24 new and unfamiliar objects.

Basic matching-from-sample performance can be analyzed into the following stimulus-response components:

1. Anticipatory self-stimulation[8] with the sample object.
2. Comparison behavior[9] with sample-object and choice-objects.
3. Positive responses to the choice-object which is the duplicate of the sample and negative responses to the remaining choice-objects.
4. Facile exchange of selection and avoidance responses to choice-objects in accordance with the frequently reversed positive and negative values of these objects in a trial series.
5. Generalization of all the above responses, i.e., matching unfamiliar sample-objects in unfamiliar groups of choice-objects.

In the pre-solution stage of matching-from-sample the subjects showed a difficulty reduction tendency by responding to the problem as a discrimination, i.e., they would perseverate in selecting a given object or the object in a given position. This behavior throws light upon a functional difference between discrimination performance and matching-from-sample performance. Discrimination behavior is characterized by stereotyped positive responses to one stimulus and stereotyped negative responses to the alternate stimulus. Such stereotyped differential responses constitute one of the simplest types of adaptive behavior and has been observed as low in the phyletic scale as the dancing mouse (48) and the painted turtle (1). On the other hand, a ready exchange of positive and negative responses to the same choice-object is characteristic of matching performance.

An important operational difference between the discrimination problem and the matching-from-sample problem is that in the former one of the choice-objects receives differential reinforcement in a trial series, in the latter all of the choice-objects receive equal reinforcement in a trial series.

[8-9]These terms are descriptive of overt stimulus-response patterns which have been recorded in motion picture films (38, 41, 43).

Each time a new set of objects is introduced into a discrimination set-up, the subject must learn a new differential response. The subject trained in matching-from-sample makes immediate correct choices with each new set of stimulus objects seen for the first time.

Because of the stereotypy which characterizes discrimination behavior, it is preferable to employ another term for the flexible differential responses to the choice-objects in matching-from-sample performance. To express the functional difference between the two types of performances the term distinguishing behavior is suggested as opposed to discrimination behavior.

The matching-from-sample method is amenable to extensive variation and scaling over a broad range of difficulty. The sample has a representative rôle in the matching situation since it serves to indicate the correct choice-object. In the basic problem this representative rôle is restricted to exact identity between the sample and its corresponding choice-object and to other fixed conditions in the stimulus field. The representative function of the sample can be progressively broadened by an appropriate training sequence so that it remains effective despite the absence of resemblance between sample and corresponding choice-object and despite other changes of stimulus conditions. Thus the sample can come to represent a broad variety of objects having a common property, i.e., a class of stimuli. This development occurred in the color categorizing experiment in which finally an uncolored triangle symbolized red choice-objects and an uncolored elipse symbolized blue choice-objects. Similarly by means of the matching method symbolic performance with forms and numbers can probably be developed in monkey subjects.

Another variant of the matching-from-sample method is the non-spatial delayed response problem. Delayed response problems since Hunter's (14) classical experiment have been frequently employed in comparative psychology as a means of studying complex adaptive behavior. With rare exceptions, the differential cues involved in these problems were spatial. The learning of delayed responses to *properties* of stimulus objects rather than to their *position* in the visual field, appears to offer great difficulties to infra-human subjects. The nature of non-spatial delayed responses is discussed in terms of "pre-linguistic sign behavior" in a recent report by Yerkes and Nissen (50).

The matching-from-sample method readily lends itself to non-spatial delayed response problems. After the subject has mastered basic matching-from-sample, progressively increased time intervals are introduced between presentation of the sample and the presentation of the choice-objects. Studies

of delayed matching-from-sample performances have been carried out by Weinstein (37, 40) in the monkey and by Finch (3) in the chimpanzee.

C. The Optimal Stimulus Apparatus

In any experimental study of animal learning, after a given type of problem has been chosen, there remains to be determined the specific nature and arrangement of the stimuli to be employed. It is clear that many possibilities are available, but all will not serve experimental objectives equally well. Of the many stimuli present in a given learning situation some tend to aid the primary cue, others tend to oppose it. The former therefore can be called *synergic stimuli*, the latter *antagonistic stimuli*. One stimulus field may be more conducive to problem solving than another, because it contains more synergic stimuli and fewer antagonistic stimuli. The optimal stimulus apparatus is designed to offer the subject the greatest possible number of synergic stimuli, and the fewest antagonistic stimuli.

The optimal stimulus apparatus used in the basic matching-from-sample procedure is represented in Figure 4. The stimulus objects are presented upon a sliding tray 8" x 24" made of 1" board. The tray is equipped with food-wells bored in a row 2" back from the front edge. The wells are 1½" diameter, ¾" deep, and are spaced 5" apart from center to center. The tray is divided by a thin strip of wood into a sample-object area having one food well and a choice-objects area containing four food-wells. A flange surrounds the tray to prevent the stimulus objects from falling.

Diverse stereometric objects are employed as the stimuli. These are placed over the food-wells, the correct choice-object concealing a food reward. The tray is illuminated from above so that it presents a field markedly brighter than the rest of the room. In making the correct selection the subject displaces a choice-object and obtains the uncovered food-reward.

Three dimensional stimulus objects have been rarely used in studies of differential responses in infra-human subjects. Planeometric stimuli such as triangles, squares, circles, etc., have been regularly employed. Observational studies[10] of monkeys in their home cage (not experimentally con-

[10] The writer has made many informal observations of reaction tendencies of monkey subjects towards visual and auditory stimuli. It was observed that if a cube and a sphere, and cards with inscribed circle or square are placed within the home cage of the monkey, he will preferentially manipulate the solid objects. He will roll the sphere and bite the corners of the cube. In handling the cards no responses were made to the inscribed figures, but rather they were treated as three dimensional objects, i.e., biting the cards and breaking them. While differential responses were made immediately to the three dimensional objects, no such behavior was observed towards the two dimensional stimuli.

trolled), indicated that they respond more readily to the properties of three dimensional objects than to those of two dimensional objects. These observations suggested that stereometric stimuli, because of their greater diversity of differential cues, would elicit differential responses more readily than would planeometric stimuli.

The stereometric stimuli of the optimal stimulus apparatus were selected to secure a wide diversity in pattern, size, color, brightness, texture, and weight. The opportunity offered the subject, of handling the stimulus objects is regarded as an important advantage of this apparatus. In forming differential responses to the objects the subject can utilize tactual and kinaesthetic as well as a variety of visual cues. Synergic stimuli are therefore available in several sense modalities. The absence of resembling properties in the choice-objects minimize antagonistic stimuli. For example, two choice-objects differing in pattern such as a cube and a sphere will nevertheless offer antagonistic stimuli in the learning of a differential response if they resemble each other in size, color, brightness, texture, and weight.

Many of the objects used in the matching-from-sample experiments were made in the laboratory of metal and of wood painted different colors. In order to secure a wider variety of stimulus objects recourse was made to such commercial articles as oil cans, flower pots, cooky cutters, vegetable cans, electric sockets, and pushbutton, tobacco tins and various other trade containers. With laboratory made and commercial objects combined a diverse selection of several hundred stimulus objects were available.

The stimulus objects were placed over food wells on a tray in order to secure the simplest possible physical arrangement of the problem situation. The selective response consists of displacing a choice-object to immediately reveal the food reward or its absence in the well beneath. The closest possible spatial and temporal contiguity exists between the correct choice and the reward. Distraction from the necessary manual response is reduced to a minimum allowing for the greatest attention upon the problem itself. After the subject has responded correctly and is obtaining the reward the solved situation remains in full view so that it can be reinforced. Likewise after an incorrect response the unsolved situation remains to be negatively reinforced.

The illumination of the apparatus was markedly brighter than that of the rest of the room in order to aid in focusing the subject's attention upon the problem situation. Two light bulbs, shielded from the subject, attached

to the front of the experimenal cage about 20" above the apparatus served this purpose.[11]

The optimal stimulus apparatus is adaptable to various types of problems requiring differential responses. It was employed by the writer in delayed matching (37), discriminative matching (40, 47) and in color categorizing (42) experiments. It was also used in a preliminary unpublished study of one trial discrimination and one trial discrimination reversal problems with the subject Corry. The maximally rapid acquisition of the discrimination responses in these problems is an indication that the conditions for learning offered by this apparatus are optimal.

D. Tuition

It is an underlying assumption of education that the individual, with the aid of guidance, can learn solutions to problems which otherwise would be difficult or impossible. This dictum is given special emphasis in pedagogical methods with pupils of low intelligence.

In contrast, the generally accepted methodology in problem solving experiments with infra-human subjects calls for the careful exclusion of guidance by the experimenter. Animal experiments have taken the customary form of testing for some capacity or ability in problem situations in which trial-and-error constitute the subject's sole means of learning. Although this method is mandatory in certain studies of learning, it imposes narrow limitations upon investigations of complex adaptive behavior.

It is of course imperative that all cues be excluded which the subject can utilize to simulate the true solution to the problem. However, this objective does not necessitate physical remoteness between experimenter and subject nor the exclusion of tuitional procedures. Yerke's findings with the experimental chimpanzee applies as well to the monkey. He writes (49, p. 263):

> It is our present experience-proved conviction that after a chimpanzee has been perfectly tamed, rendered at home in its laboratory environment with the investigator, it is wholly desirable to substitute demonstration and patient training by example for the usual let-it-alone, cut-and-dried, standardized procedures which we use with such laboratory animals as mouse, rat, rabbit, or guinea pig. This procedure is actually our nearest equivalent to the verbal description and instruction which we ordinarily offer the human subject, and in our use it is strictly comparable with the treatment which we should expect to accord a human infant or defective incapable of verbal communication.

[11]Bulbs of various wattages were tried—from 250 watt photo-flood bulbs to the 75-watt light bulbs used towards the end of the experiment. Determination of the optimal value was not made.

The method of tuition employed in the matching-from-sample and color categorizing experiments contained three factors which favored learning. (*a*) A stepwise training sequence from the simple to the complex was utilized so that each stage prepared the subject for the next until the desired performance was reached. (*b*) Supplementary cues were given by the experimenter in the early phase of training. (*c*) High motivation was secured by giving the greatest amount of preferred food incentive consistent with sustained appetite during the training session and by utilizing social incentives, i.e., vocal disapproval after errors and vocal approval after correct responses.

Training in the basic matching-from-sample problem was begun with the simplest possible choice situation on the optimal stimulus tray—a sample-object in the sample-object area, and two choice-objects in the choice-objects-area. The choice-objects were carefully selected to offer large contrasts in size, pattern, color, brightness, texture, and weight.

The tray with the stimulus objects was presented to the subject just out of his reach. In order to focus the subject's attention on the tray, a piece of banana, his preferred food, was held above it. With the subject looking on, the banana was placed into one of the food wells in the choice-objects-area and covered with the positive choice object. This was the duplicate of the sample in the current trial. Simultaneously the negative choice object was placed over the other food well, which was empty. Then the subject was orientated towards the sample-object-area with another piece of banana which was placed into the food well there and covered with the sample. The tray was then immediately pushed forward, the subject would displace the sample and secure the food under it, and then shift over to the right to displace the corresponding choice-object under which he had just seen the banana placed. Thus training was initiated with correct choices shown to the subject.

After the subject had formed the habit of commencing each trial by attending to and displacing the sample, a piece of non-preferred food, apple instead of banana, was placed beneath it. The preferred food, banana, was now obtained by the subject only after displacement of the correct choice object. High motivation was thus maintained until a choice had been made and the interval between contact with the sample and the selection of a choice-object was reduced to a minimum—about one second. Each successive stage was introduced after the criterion of 23 correct choices in 25 trials was reached.

In the next stage, the banana reward and the choice objects were placed into position behind an opaque screen. The tray was then pushed forward

and a piece of apple was placed beneath the sample in view of the subject. The experimenter gave the subject help when he showed hesitation in making a choice by slightly moving the correct choice object, but not exposing the reward under it.

Next an opaque screen separated the subject from the experimenter while the food and the stimulus objects were being placed into position. The screen was then raised and the tray pushed towards the subject who now regularly orientated towards the sample at the beginning of each trial. For about five seconds the tray was held just out of reach of the subject, who would make oscillatory head and trunk movements between sample and choice objects—an overt act of comparison. The tray was then pushed completely forward, i.e., against the experimental cage. The subject first displaced the sample and then either a correct or incorrect choice object.

In order to further reinforce the correct matching response the solved situation was allowed to remain for several seconds before the subject as the experimenter handed him an extra food reward. Vocal approval was also given immediately after completion of the trial. The experimenter gave negative reinforcement to all incorrect responses by pronouncing the word "no." The correct choice-object was then indicated to the subject by lifting it to reveal the unattained reward.

In the next stage of training the food under the sample object was discontinued. Fixating and touching the sample became a stable unrewarded response anticipatory to selecting a choice object.

In a series of further training steps new stimulus objects were introduced and the number of choice objects was increased to four (see 37). The basic matching-from-sample problem was terminated with a critical trial series in which all cues from the experimenter were excluded and a new set of stimulus objects used.

In order to develop correct responses in the delayed matching problems (37, 40), it was considered necessary that the subject acquire the habit of prolonged self-stimulation with the sample before the delay. Touching the sample for an instant when it was presented was a response which was learned in the basic matching-from-sample problem. Tuition now took the form of pushing the sample forward or handing it to the subject until he learned to fixate and manipulate it for several seconds. In training the subject in the delayed matching problems, the delay intervals were successively lengthened from 0 to 5, 10, 15, 30, and finally to 60 seconds. Training sessions were always begun with five no-delay warming up trials.

The final performance in the color categorizing problem involved the

sorting out of red and blue objects in a highly complex stimulus situation. The steps employed to develop color categorizing performance has already been described (42). In this experiment, in order to more strongly reinforce correct responses, after a trial was successfully completed the experimenter juxtaposed the sample and corresponding choice objects as the subject looked on, and immediately handed it another food reward.

In all experiments the subjects were trained seven days a week. In rare exceptions one day was omitted. Occasionally the training session was discontinued because of frustrated behavior in the subject. The number of training trials in each session ranged from 10 to 30, depending upon the problem.

The rôle of tuition in forestalling responses to secondary cues is worth noting. It is well known in animal studies that the greater the difficulty of the problem the greater the tendency of the subject to simulate correct responses by means of secondary cues. Tuition reduces the difficulty of the problem and also enables the experimenter to observe with greater certainty the cues to which the subject is responding.

E. Taming Method

The organism which is emotionally unadjusted to its environment is not prepared to respond to it intelligently. Untamed laboratory monkeys show a marked lack of adjustment in comparison with dogs, cats, or even white rats. Their behavior towards the experimenter varies between fearful withdrawal, and acts of aggression such as biting or scratching. When placed into the experimental cage they walk around in circles, shrink into a corner, bite the wooden framework, and only incidentally pay attention to the problem situation. Such notable lack of disciplined responses in monkeys not adequately conditioned to the laboratory routine has prompted Thorndike (33) to observe that,

> . . . the behavior of monkeys, by virtue of their inconstant attention, decided variability of performance, and generally aimless unfortellable conduct would be falsely represented in any clean cut, unambiguous, emphatic exposition.

The problem of developing coöperative behavior in experimental infrahuman primates has been discussed at length by Yerkes (49), Kellogg (17), and Tinklepaugh (35). This problem is analyzed by these writers from several points of view and basic methodological principles are enunciated.

The following is a description of the training procedure employed by the

present experimenter in order to properly prepare monkey subjects for training in problem solving.

Two subjects were paired in one living quarter, because preliminary observations indicated that monkeys behave less fearfully with a permanent cage mate. The mutual dependence between such a friendly pair could be seen in their agitated and vocal bodily behavior when separated. The play behavior which familiar cage mates develop is to be regarded as having a favorable value on the temperament of the animals.

The plan of graded transitions was applied in the taming as well as in the tuitional procedure. In the beginning taming sessions, the experimenter with a supply of peanuts and cut fruit would sit on a low stool in the home cage of the monkeys. Within their familiar environment the subjects were more amenable to taming than when taken out. The cage was large enough to allow the animals to remain at a distance of several feet when they so preferred. Pieces of food were tossed to the monkeys, who would come down from their perches to pick them up. Food was next tossed to a point closer to the experimenter, thus inducing the animals to make nearer approaches. Fear responses were gradually extinguished and the monkeys would finally approach the experimenter to take food from his hand. In each session the experimenter sought to obtain the greatest possible number of approach responses. The frequency of approaches was regarded as a measure of taming progress.

Experience has shown that this taming procedure not only adjusts the monkeys to the experimenter but also is helpful in training new laboratory assistants to work with monkey subjects.

During the process there occurred social facilitation between the cage mates; that is, both the submissive and the dominant of the pair encouraged the other to compete for food in the experimenter's hand. Vocal stimuli, calling the monkeys by name, were used and food rewards were immediately given when the subjects approached. Collar and leash, which in monkeys give rise to traumatic stimuli, were excluded; and constant care would be taken to avoid inadvertent frightening stimuli such as a rapid gesture.

After about two weeks the taming was directed towards getting the monkeys to submit to handling and to become coöperative in the laboratory routine. A harness was made, so that a pull was exerted upon the chest of the monkey rather than upon the neck. The subject was called and gently pulled towards the experimenter, and then fed and handled simultaneously. Attempts to bite were discouraged by a vocal "no" and a tap on the body. This vocal stimulus which elicited an inhibiting response proved

its usefulness later during training when the subject was required to refrain from touching negative stimulus objects.

After approximately another week the daily trip to the experimental room was begun. Subjects were called, picked up, and rewarded with their preferred food and then carried to the experimental room together. One was placed in the experimental cage, and the other in an adjacent cage. Liberal feeding of fruits and nuts were continued here. Thus the experimental room became a locus of large rewards to the subject.

While one monkey was being trained in a problem the other was always kept in the adjacent cage for the sake of social facilitation. That this factor was important could be clearly seen by the poor performance of a monkey tested without its partner in the room. In the tamed subjects it was possible to control frustrated behavior which appeared during difficult problems, by vocal reassurance and by feeding preferred food between trials.

With monkeys tamed by means of the above taming procedure, performances in both visual acuity tests (45, 46) and in problem solving situations were obtained which could not be secured with other subjects. Such tame animals make feasible the use of detached stimulus objects. The subjects could be trained to manipulate the detached objects in directed problem solving performance with a minimum of random handling. The disciplined behavior with the freely manipulable stimulus objects is a basis for complex types of problem solving performances.

F. Summary

A methodology is described which has been found effective in studies of complex adaptive behavior in monkey subjects.

The techniques which were employed are: (*a*) basic-matching from sample; (*b*) the optimal stimulus apparatus; (*c*) tuition; (*d*) taming method.

By means of these techniques, problem solving performances were developed in monkey subjects homologous to those required in matching and sorting items in human intelligence tests.

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PERCEPTUAL BEHAVIOR OF BRAIN-INJURED, MENTALLY DEFECTIVE CHILDREN: AN EXPERIMENTAL STUDY BY MEANS OF THE RORSCHACH TECHNIQUE*

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I. INTRODUCTION, SUBJECTS, AND PROCEDURE

For a number of years, studies have been conducted at the Wayne County Training School with the purpose of detecting essential differences in psychological functioning between clinical types of mentally deficient children. It has been shown that children whose mental deficiency is related to an early acquired damage to the brain, are impaired in sensory-motor functions and in perceptual integrations. They also show a disturbance in conceptual thinking, which distinguishes them from non-brain-injured children of the same level of intelligence, as measured by the Binet test.

Since the interpretations of Rorschach's ink-blots involve perceptual and conceptual functions, one should therefore expect that the two groups of mentally defective children, one brain-injured, the other non-brain-injured, should react in a characteristically different way to the inkblots.

That such a study was conducted after significant results had been obtained in the earlier experiments, carries the advantage that its findings can be interpreted and discussed in the light of previous experimental and clinical evidence.

A. Subjects

Two groups of children, all boys, selected from the population of the Wayne County Training School[1] participated in this study. One group consisted of 19 boys diagnosed as brain-injured (exogenous type of mental deficiency), the other as non-brain-injured (endogenous or familial type of mental deficiency). Each member of the first group was closely matched with a member of the other group, according to mental age and *IQ*.

Diagnosis of brain injury[2] was based on three criteria (Strauss, 16): (*a*) evidence from the developmental history, of a prenatal, natal, or post-natal injury to the brain; (*b*) absence of feeblemindedness in the immediate family; (*c*) presence of neurological signs indicating a brain lesion. Children with signs of endocrine disturbances, syphilitic processes, and hereditary diseases were excluded from this group.

Diagnosis of endogenous (familial) type of mental deficiency rested on negative findings in the neurological examination and clinical record, as to central nervous system lesions, and on the evidence of feeblemindedness in the immediate family history.

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[1]The Wayne County Training School is an institution devoted to the training and rehabilitation of children of moron and borderline intelligence.

[2]Since it is frequently believed that "brain-injured" children are those who show gross motor disturbance (spasticity, athetosis, ataxia) it should be explicitly stated that our brain-injured subjects were free from gross motor defects. Their main overt sign of brain injury was mental impairment, not disturbance of gross motor function.

In Table 1 are shown the ranges and means of the chronological and

TABLE 1
RANGE AND MEAN OF *CA*, *MA*, AND *IQ* OF BRAIN-INJURED AND ENDOGENOUS GROUP

	CA		*MA*		*IQ*	
	Range	Mean	Range	Mean	Range	Mean
Br-In.*	11-11 to 16-0	14.7	8-1 to 12-3	10-2	63-87	72.4
End.**	12-1 to 15-7	14-6	8-2 to 12-0	10-2	58-83	72.7

*Brain-Injured.
**Endogenous.

mental ages, and *IQ*'s, separate for each group. It may be noted that the members of each matched pair did not differ from each other more than three months in their mental ages and more than five points in their *IQ*'s.

B. Procedure

The procedure employed in this experiment was essentially the same as the one used by the majority of Rorschach test examiners. The test was administered only if the child appeared sufficiently relaxed and in good physical condition. The verbal record followed the utterances of the child as closely as possible. The graphical recording was done on mimeographed, schematic copies of the ink-blot cards, so that on each copy the portions related to the various responses were outlined and designated. After the child had given his interpretations to one card, he was questioned by the examiner for further information as to what factor determined the responses (shape, color, movement, etc.).

These children frequently have a short memory span; it was not expected of them to remember their responses to a card too well, after other cards had been presented to them. Therefore, no interlocution was attempted after all 10 cards were presented.

Our procedure departed, somewhat, from the usual technique in one respect. We probably prodded the children for responses more frequently than would many examiners. Since we attempted to conduct our study as we would any other experiment on perception, rather than as a routine personality test, we were anxious to obtain responses to all cards by all children. Everybody who is acquainted with the sluggish behavior of many of the subnormal children will agree with the necessity of some prodding. It is

likely that a somewhat higher average number of responses than one would have otherwise received, resulted from such stimulation. However, some evidence will be presented later to show that the stimulation did not have an appreciable effect on the relative differences between the brain-injured and non-brain-injured groups.

II. THE RESULTS

In this section only the results will be presented without an attempt at interpretation. All discussion with findings of previous investigators taken into account will be offered in the next section.

A. Number of Responses

The results presented in Table 2 indicate a considerable difference in the number of responses obtained from the two groups of children. Brain-injured children produced fewer interpretations than the children of the endogenous type. The brain-injured group gave a total of 614 responses; the endogenous group a total of 846. An average of 32.3 responses to the

TABLE 2

Number of Responses

	Total	Nu. p. child	$p(t)$
Br.-In.	614	32.3	$<.01$
End.	846	44.5	

whole set were given by a brain-injured child, and 44.5, by a non-brain-injured child. These differences, according to the test pertaining to related measures, are statistically significant at the one per cent level of confidence (11, p. 59).

B. Area of Response

One aspect of the qualitative analysis concerns the region of the ink-blot to which the interpretation pertains. Responses to the colored or shaded areas (whole and detail responses) are to be distinguished from those to the white spaces.

1. *Whole and Detail Responses*

The examiner can easily distinguish the responses pertaining to the whole inkblot from those pertaining to blot details. The definition of various types of detail responses is less clear-cut. For the purpose of this study the discrimination between ordinary or normal details (*D*), uncommon details (*Dr*), tiny details (*dd*) and so-called oligophrenic details (*Do*) appears sufficient. Whether a detail response is normal or uncommon is decided by statistical analysis of responses of a normal population. As a basis for our scoring, the frequency tables compiled by M. Hertz (7) for each of the ink-blots were employed. It was a fortunate coincidence for this compilation that the chronological age range of the 300 subjects which

Miss Hertz used in her work were the same as that of our groups, 12-16 years. The distribution of the responses to the whole ink-blot and to various types of details are presented in Table 3.

In this table, as in all subsequent tables, a threefold computation has been obtained for each response type, viz.: (*a*) the total number of such responses produced by the group; (*b*) the average number, per child, of each group; (*c*) the percentage of the responses with regard to the total interpretations made by the group.

2. *Whole Responses (W)*

Though no differences in the absolute number of whole responses had been found between the two groups, there was a noticeable difference in the percentages of these responses between the two groups: with respect to the total output, brain-injured children interpreted the whole blot more often than did the non-brain-injured group. This difference, 20.7 per cent whole responses in the brain-injured group against 14.9 per cent in the endogenous group, is significant at the one per cent level of confidence according to Chi-Square analysis.

3. *Responses to Ordinary Large Details (D)*

The quantitative relationship of these reactions in the two groups is somewhat similar to that of the whole responses. Absolutely, more usual detail responses were given by the endogenous group; percentally, however, the number of ordinary detail responses was greater in the brain-injured group (52.3 per cent against 46.4 per cent). This difference in percentage is significant only at the 3 per cent level, according to the Chi-Square test.

4. *Responses to Uncommon Details (Dr)*

Under this heading, responses were computed which were infrequently found in a normal population; it will be noticed that we excluded the tiny and "oligophrenic" detail responses which will be discussed separately below. Uncommon detail responses were numerous in both groups. No significant differences between the two groups were found; the percentages of responses were practically the same (16.6 and 19 per cent respectively).

5. *Tiny Detail Responses (dd)*

The number of reactions to extremely small areas, consisting of specks, dots, or tiny protrusions, differed greatly in both groups. Almost no tiny details were perceived by the brain-injured children, whereas 16.5 per cent

TABLE 3

WHOLE AND DETAIL RESPONSES

	W			*D*			*Dr*			*dd*			*Do*		
	Tot.	p.child	%	Tot.	p. child	%	Tot.	p. child	%	Tot.	p. ch.	%	Tot.	p. ch.	%
Br. In.	127	6.7	20.7	321	16.9	52.3	102	5.4	16.6	6	.3	1.0	34	1.8	5.5
End.	126	6.7	14.9	393	20.7	46.4	160	8.4	18.9	140	7.4	16.5	14	.7	1.7
p (Chi-Squ.)			$<.01$			$<.03$			$>.05$			$<.01$			$<.01$

of the total responses of the endogenous referred to these extremely small parts of the blots. This is a statistically highly significant difference.

A criticism against any conclusion reached from these results could be raised. One could argue that the greater amount of tiny detail responses in the endogenous group should not be related to a true difference in perceptual behavior but could be explained simply as a consequence of the group's larger total number of responses; that is, after having exhausted, by their numerous responses, the possibility of interpreting bigger details, they necessarily would have to turn to smaller and smaller parts. In order to test the validity of this critique, the first three responses to each card were selected for computation. Thus, 535 responses were left out of consideration; 456 responses of the brain-injured group, and 469 of the endogenous group remained as a basis for the new calculation. Only 4, or .9 per cent, of the responses of the brain-injured children referred to tiny details against 55, or 11.7 per cent, of the reactions of the endogenous group. In other words, the results found in the previous computation are not substantially altered; non-brain-injured children, in contradistinction to brain-injured, responded noticeably, even in their initial reactions, to tiny parts of the blots. The attempt to explain the higher frequency of those responses in endogenous children by their larger total number of interpretations can therefore be considered invalid.

6. *Oligophrenic Details (Do)*

A response is termed "oligophrenic" when a subject sees an isolated part of a figure usually perceived as a whole. Feet, hands, or other parts of the human body seen as independent details without perceiving the rest of the person are such oligophrenic details. Rorschach (15, p. 40) seemed to consider as oligophrenic only parts of the human body. We follow the usage of later authors, such as M. Hertz, who have extended the term to animal parts. The term "oligophrenic detail" was coined by Rorschach because he assumed that it was characteristic of the records of feebleminded subjects. Our results are particularly interesting with reference to this assumption.

Oligophrenic details were infrequent in the records of our endogenous children; only 1.7 per cent of all responses belong to this type. Brain-injured children had three and one-quarter times as many oligophrenic detail responses (5.5 per cent). This difference between the two groups is statistically significant at the one per cent level, according to the Chi-Square test.

7. *White Space Responses (S)*

These are responses which consist in the selection and interpretation of white areas lying either inside or outside of the blot. Two forms of *S*-responses may be distinguished. The one form is based on a reversal of the configurational relationship between blot and white area. The white area usually building the background becomes the figure, the blotted parts the surrounding ground. Such a response is scored as the *S*-response proper (*S*). There are responses in which the white space is used as a part of a perception mainly formed by the blotted parts. If, for instance, the white center part of Card II is interpreted as "lamp" we are dealing with a reversal of figure and ground. If interspersed spaces are used to designate a lake or a road in a scene formed by shadow parts we are dealing with an *S*-response of the secondary type. Secondary *S*-response are scored according to the blot area involved, either as whole *S*- or detail *S*-responses, with the signs *WS* or *DS*.

The responses of the brain-injured group (Table 4) contained significantly more reversals of figure and ground, that is, *S*-reaction of the first

TABLE 4

White Space Responses

	WS + *DS**			*S*			Sum *S*		
	Tot.	p. ch.	%	Tot.	p. ch.	%	Tot.	p. ch.	%
Br.-In.	60	3.2	9.7	24	1.3	3.9	84	4.5	13.6
End.	39	2.0	4.5	13	.7	1.5	52	2.7	6.0
p (Chi-Squ.)			$<.01$			$<.01$			$<.01$

*Also scored under *W*, *D*, or *Dr*.

kind, than did the non-brain-injured group; they excelled, also significantly, in white space responses of the secondary type. The difference in the number of white space responses of both kinds between the two groups (13.6 per cent versus 6 per cent) is significant at the one per cent level of confidence, according to the Chi-Square analysis.

C. The Movement Responses

1. *Human-, Animal-, Object-Movement*

The type of response to the ink-blots which Rorschach calls the movement response is perhaps the most difficult to determine. From the point of view of systematic psychology the term "movement" is not quite adequate. According to Rorschach a "kinaesthetic" or movement response comes about

by projecting one's own bodily reactions into the visual field. Such perception, limited to human and human-like actions,[3] would probably more correctly be termed "empathetic response." Various investigators subsequently have extended the range of movement responses to animals and objects; they differentiate between human or human-like action, animal or animal-like action, and activity seen on objects.

In view of a certain ambiguity and subjectivity which is inherent in the scoring of movement perception, the movement responses have been scored here in several ways. First we discriminated between two types of animal-movement responses. One, called here *MFM*, pertains to human-like movements of animals, such as "bears kissing." Many of these responses are traditionally scored by Rorschach and his followers as human movements. The other type of response contains animal movement proper.

Furthermore, the movement responses were tabulated altogether under two different points of view. In the first place, of the responses which contained the description of movement, only those were defined as either human- or animal-movement responses of which we were reasonably sure that some sort of empathetic reaction was actually involved in the perception.

Some people believe, however, that the distinction between responses based on kinaesthetic experience, and responses, though stating ideas of movement, but lacking the kinaesthetic feeling of it, is either arbitrary, and therefore not scorable, or theoretically not correct. In a second tabulation the criterion of kinaesthetic experience was therefore omitted. All reactions expressing movement were counted irrespective of whether or not empathetic experience was thought to be involved. Such an approach may be defended on the assumption that interpretations of the ink-blots in terms of movement, are, at least to a certain degree, an indirect measure of underlying movement experiences. In other words: if the two groups should be found to differ reliably in the number of such movement responses one might assume that at least one cause of this discrepancy ought to be traced to differences of this perceptual aspect.

Though the two methods of movement analysis may not measure exactly the same thing, together they should give a clearer and more complete picture of psychological functions involved in the so-called movement responses.

The results of the two methods of computation are presented in Tables 5 and 6. By comparing the tables, one will note that the results, in general,

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[3]For example; Card III: "*Two men reaching for something.*"

TABLE 5
MOVEMENT RESPONSES IN RESTRICTED SENSE (EMPATHETIC)

	M Tot.	*M* p. ch.	*M* %	*MFM+FM* Tot.	*MFM+FM* p. ch.	*MFM+FM* %	*m* Tot.	*m* p. ch.	*m* %	Σ Mov. Tot.	Σ Mov. p. ch.	Σ Mov. %	*M/ MFM+FM*	*M+MFM/ FM*
Br.-In.	17	.9	2.8	5+18	.3+ .9	.9+2.8	8	.4	1.3	48	2.6	7.8	76:100	121:100
End.	29	1.5	3.4	15+58	.8+3.0	1.7+6.9	10	.5	1.1	112	5.8	13.2	39:100	75:100
p Chi-Squ.)			>.05			<.01						<.01		

TABLE 6
MOVEMENT RESPONSES IN UNRESTRICTED SENSE

	M Tot.	*M* p. ch.	*M* %	*MFM+FM* Tot.	*MFM+FM* p. ch.	*MFM+FM* %	*m* Tot.	*m* p. ch.	*m* %	ΣMov. Tot.	ΣMov. p. ch.	ΣMov. %	*M:FM+MFM*
Br.-In.	48	2.5	7.8	57	3.0	9.2	6	.3	1.0	111	5.8	18.1	85:100
End.	54	2.8	6.5	147	7.7	17.4	20	1.1	2.3	221	11.7	26.1	37:100
p(Chi-Squ.)			>.05			<.01			[.03]			<.01	

concur in reference to certain differences between the two groups irrespective of whether the first or second method of computation has been applied. The results may be briefly enumerated. (*a*) *The brain-injured children gave altogether fewer movement responses:* 7.8 per cent of all interpretations of brain-injured children contained movement of the empathetic type against the 13.2 per cent given by the endogenous group. This difference is significant at the one per cent level, according to Chi-Square analysis. Applying the second method of analysis, that is, counting all movement responses indiscriminately, no essential change of the results was found. Though the relative difference between the two groups is smaller (18.1 per cent versus 26.1 per cent), the number of movement responses produced by the endogenous group was significantly larger than that of the brain-injured group. (*b*) No significant difference was found between the responses of the two groups dealing with human-movement. (*c*) There were considerably fewer animal-movements perceived by the brain-injured as compared with the non-brain-injured group. Counting only the empathetic reactions, the per cent ratio is 3.7:8.6. The percentage of animal-movement responses, counted without restriction to empathy, were similar: 9.2 per cent were given by the brain-injured, and 17.4 per cent by the endogenous group. In other words, both calculations show that endogenous children gave about twice as many animal-movement responses than did the brain-injured. These differences are significant at the one per cent level according to Chi-Square analysis. (*d*) Though no significant difference has been noticed between the human-movement responses of the two groups, a considerable difference exists between the ratios of human-movement reactions to those containing animal-movement. In relation to the movements of animals, there were about twice as many movements seen in human figures by the brain-injured group. That is: taking the number of animal movements as 100, the ratio for the brain injured group was 76:100, for the endogenous group 39:100.[4] These figures, pertaining to the empathetic movements, were not considerably altered if the computation was based on movement responses without restriction. (*e*) Responses containing movement of objects were rare. Counting the responses without restriction to empathy, endogenous children tended to produce more of these answers than brain-injured children. The difference was significant only at the three per cent level, according to the Chi-square test.

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[4]If one wants to score the *M* responses according to the traditional Rorschach computation, one would have to add *MFM* of Table 5 to *M* instead of to *FM*. The ratio *M*:*FM* would then be 121:100 for the brain-injured, and 75:100 for the endogenous group.

2. *Types of Activity Expressed in the Movement Responses*

A further discrimination of movement responses was attempted with respect to forms of activity. Three forms seemed to stand out clearly in such classification; they may be termed as "action," "expression," and "posture." (*a*) "Action" was understood to be any explicit, actual movement in space, such as flying, walking, pinching, rolling down, etc. (*b*) By the term "expression," we mean any expressive movement such as smiling, staring, looking, pointing, barking, etc. (*c*) "Posture" refers to body positions, described in the responses as standing, leaning, lying, hanging, sitting, etc.

Most responses could be classified unambiguously according to one of the three categories. There were only few instances where the classification was somewhat difficult. For example "sniffing" could probably be classified under "action" as well as under "expression." We counted it under the latter category since sniffing seemed to us predominantly an expressive movement. Likewise "sleeping" was classified as posture, since lying still seemed to be the predominant characteristic of the content of the perception. The following results (Table 5*a*) were obtained in regard to the three categories

TABLE 5*a*

DISTRIBUTION OF MOVEMENT RESPONSES IN TERMS OF ACTION, EXPRESSION, POSTURE

	Ac.	Ex.	Po.	Ac/ΣMov.	Ex/ΣMov.	Po/ΣMov.
Br.-In.	23	15	10	.48	.31	.21
End.	75	33	4	.67	.29	.04
p(Chi-Sq.)	<.01	>.05	[<.01]			

TABLE 6*a*

UNRESTRICTED MOVEMENT RESPONSES IN TERMS OF ACTION, EXPRESSION, POSTURE

	Ac.	Ex.	Po.	Ac/ΣMov.	Ex/ΣMov.	Po/ΣMov.
Br.-In.	48	25	38	.43	.23	.34
End.	135	68	18	.61	.31	.08
p(Chi-Squ.)	<.01	.05	<.01			

of movement. Movement responses of the action type were significantly more frequent with the endogenous than with the brain-injured group. On the other hand, responses indicating postures were significantly more often produced by the brain-injured children. The significance of these differences is at the one per cent level, according to the Chi-Square test. These differences obtained, whether or not the movement responses were restricted to empathetic perception. Movement responses of the expressive type, though

more frequent with the endogenous children, did not differentiate significantly between the two groups.

The inverse relationship of the distribution of action and posture responses was still more apparent if the amount of the three types of responses was calculated according to the total of movement responses. With the brain-injured group, the percentage ratio for action versus posture was 48:21; with the endogenous group, 67:4. These figures were obtained with movement responses restricted to empathy. The ratios tabulated from unrestricted movement responses were 43:34, for the brain injured, and 61:8 for the endogenous. Thus, we may again note that posture responses, extremely rare in the endogenous group, were present to a considerable degree in the brain-injured group.

D. The Responses to Color

Interpretation of colored blots may be based entirely on the color with complete disregard of form (pure *C* responses). Or it may be determined by color and form as well; in this case either color or form may be the dominant factor (*CF*, *FC* responses).[5] In Table 7 the distribution of the various types of color responses with respect to the two groups has been presented. It will be noted that one type of color response, i.e., the color naming, has been omitted. The naming of colors without further interpretation, very rare with normal subjects, has been observed with brain-injured adults; we found hardly an incident of color naming in our children. According to Table 7, no significant differences were found with respect to the form-color responses. The groups differed with regard to the color-form responses; the percentage of color-form responses were higher with the brain-injured group. This difference was, however, small and not significant statistically. The pure color responses differ clearly in the two groups. There were practically no color responses given by the endogenous children, whereas 2.2 per cent of the total number of interpretations of the brain-injured children were color responses. Though this percentage is small, one has to remember that pure color responses are rare within a normal population. The difference is statistically significant at the one per cent level according to Chi-Square analysis.

[5]For readers not acquainted with the Rorschach test, a few examples may serve as illustrations: A pure color response is the interpretation of shapeless red blots as fire, blue blots as water. A *CF* response in which color is definite, form less definite, is the interpretation of red blots as a "bouquet of flowers." A form-color response may be illustrated by the interpretation of blue rectangles as "flags." Here the percept is based primarily on form, but also influenced by color.

TABLE 7
COLOR RESPONSES

	FC			CF			C			Color score*		
	Tot.	p. ch.	%	Tot.	p. ch.	%	Tot.	p. ch.	%	Tot.	p. ch.	%
Br.-In.	31	1.6	5.0	20	1.1	3.3	14	.7	2.2	56.5	3.0	9.2
End.	40	2.1	4.7	18	.9	2.1	1	.1	.1	39.5	2.0	4.5
p (Chi-Squ.)			>.05			>.05			.01			

*Termed C_{sum} by Rorschach.

TABLE 8
ACHROMATIC AND SHADING RESPONSES

	FC'			C'F			k			K			FK			Fc		
	Tot.	p. ch.	%	Tot.	p. ch.	%	Tot.	p. ch.	%	Tot.	p. ch.	%	Tot.	p. ch.	%	Tot.	p. ch.	%
Br.-In.	7	.4	1.1	6	.3	1.0	7	.4	1.1	7	.4	1.1	7	.4	1.1	12	.6	1.9
End.	10	.5	1.2	0	0	0	0	0	0	9	.5	1.1	5	.3	.6	12	.6	1.4

FC', *C'f*: Achromatic color responses with predominance of form or color respectively.
k: Shading; three dimensional objects projected on plane (X-ray).
K: Shading diffuse (clouds).
FK: Shading, three-dimensional objects in perspective.
Fc: Shading; texture (fur).

TABLE 9
FORM RESPONSES

	F+			F—			Sum F			F+%
	Tot.	p. ch.	%	Tot.	p. ch.	%	Tot.	p. ch.	%	
Br.-In.	350	18.4	57.1	107	5.6	17.4	457	24.0	74.7	76.7
End.	436	22.9	51.5	203	10.7	24.0	639	33.6	75.6	68.3
p (Chi-Squ.)			<.02			<.02			>.05	<.01

Reading the table from left to right it will be noticed that the discrepancy between the two groups in the various forms of color responses increases with the increase of color as a determining factor. By taking into account the varying degrees of influence which color exerts in the three types of responses one may, according to Rorschach, calculate a color score for each group. Such a formula is based on weights of color varying with the response type. The color weight for a form-color response is ½, for color-form response 1, for pure color response 1½. Thus, the color total can be calculated from the formula: C sum (color score) $= \dfrac{1FC + 2CF + 3C}{2}$. According to this scoring method the total color score, relative to the total number of responses of each group, is about twice as high in the brain-injured as in the endogenous group.

Responses to Achromatic Colors and Shadings

More recent investigators have extended the original analysis by Rorschach to interpretations based upon the perception of achromatic colors and shadings. Responses in which grey and black colors are determining factors were infrequent with our subjects; the differences in the number of such responses were statistically insignificant. Table 8 summarizes the results.

E. Form Responses

An interpretation based on the shape or contour of the blot is called a form response. There are good and poor form responses. Good form responses ($F+$) are frequent with normal subjects; such interpretations are easily understood by any other observer. Poor form responses are less frequent; they are incongruous with reference to the blot area involved. The form responses given by our children were scored plus and minus according to the frequency tables computed by Miss Hertz.

In Table 9, the distribution of good and poor form responses, and the total number of form responses, have been calculated for both groups. The table also shows the so-called F+ per cent, that is the percentage of good form answers with respect to the total number of form answers of each group. The results may be briefly enumerated: (*a*) The total number of form responses, though somewhat higher with the endogenous children, did not differentiate significantly between the two groups. (*b*) The brain-injured group produced a considerably higher percentage of good form responses. (*c*) The endogenous children gave more poor form responses. Both differ-

ences were significant at the two per cent level according to the Chi-Square analysis. (*d*) The brain-injured group produced a higher $F+$ per cent. This difference was significant at the one per cent level according to Chi-Square analysis.

It could be argued that the lower performance of the endogenous group was due to the greater number of responses; since the possibility of good forms are limited, a child producing many responses may tend to accept less accurate interpretations after the good form responses have been exhausted. The validity of this argument was tested by using for computation only the first three answers of each child to each card. This new computation did not alter essentially the foregoing results. There were, to be sure, fewer poor form answers in both groups. But the endogenous children still had a considerably higher number of poor form responses than the brain-injured: 58, that is 12.9 per cent poor form responses were given by the brain-injured, and 86, that is 18.4 per cent by the endogenous group. The argument that the better performance of brain-injured children was due to their fewer responses, and thus might not be indicative of their manner of perception, can therefore be refuted.

F. Content of Responses

The content of the responses is a further aspect of Rorschach's analysis. There are three main categories into which the majority of the responses can be classified: human figures, animal forms, and objects comprise the bulk of interpretations. Minor categories appearing in the responses of our children are those of botanical, geographical forms, landscape, natural events, architecture, and abstract configurations.

The three principal categories, Human, Animal, Object, have been further subdivided as follows:

Human

(*a*) Living human forms (*H*)
(*b*) Independent parts commonly seen as representative of the human body, such as head, face (*HD*)
(*c*) Piece-like parts of the human body, such as foot, hand, finger (*HD*)
(*d*) Anatomical human forms (*HAt*)
(*e*) Artificial likenesses of the human body, such as statues (*HObj.*)

Animal

(*a*) Live animal forms (*A*)
(*b*) Independent parts representative of the animal body (*AD*)
(*c*) Piece-like parts (*Ad*)
(*d*) Anatomical forms (*A At*)

TABLE 10
RESPONSES AS TO CONTENT

a. Human Responses

	H			*HD*			*Hd*			*HAt*			*HObj.*		
	Tot.	p. ch.	%	Tot.	p. ch.	%	Tot.	p. ch.	%	Tot.	p. ch.	%	Tot.	p. ch.	%
Br-In.	66	3.5	10.6	18	.9	2.9	24	1.3	3.9	7	.4	1.1	13	.6	2.1
End.	75	4.0	9.0	26	1.4	3.1	18	1.0	2.1	2	.1	.2	10	.5	1.1
p (Chi-Squ.)			$>.05$			$>.05$			$>.05$						$>.05$

b. Animal Responses

	A			*AD*			*Ad*			*AAt*			*AObj.*		
	Tot.	p. ch.	%	Tot.	p. ch.	%	Tot.	p. ch.	%	Tot.	p. ch.	%	Tot.	p. ch.	%
Br-In.	215	11.4	35.2	33	1.7	5.4	24	1.3	3.9	1	.1	.2	10	.5	1.6
End.	327	17.2	38.6	72	3.7	8.5	23	1.2	2.7	9	.5	1.1	13	.7	1.5
p (Chi-Squ.)			$>.05$			$<.03$			$>.05$						$>.05$

c. Object Responses

	Ou			*Ot*			*Op*		
	Tot.	p. ch.	%	Tot.	p. ch.	%	Tot.	p. ch.	%
Br.-In.	43	2.3	7.0	17	.9	2.8	29	1.5	4.7
End.	45	2.4	5.3	32	1.7	3.8	8	.4	.9
p (Chi-Squ.)			$>.05$			$>.05$			$<.01$

TABLE 10 (*continued*)

d. Miscellaneous Responses

	Geog. forms & maps Tot.	p. ch.	%	Nat. forms Tot.	p. ch.	%	Bot. forms Tot.	p. ch.	%	Others Tot.	p. ch.	%
Br-In.	25+ 6	1.3+ .3	4.1+1.0	34	1.8	5.9	36	1.9	5.5	13	.7	2.2
End.	40+33	2.1+1.7	4.7+3.9	38	2.0	4.5	52	2.7	6.1	23	1.2	2.7
p (Chi-Squ.)			<.03			>.05			>.05			>.05

e. Sums and Ratios

	Sum Hum. Tot.	p. ch.	%	Sum Anim. Tot.	p. ch.	%	Sum Obj. Tot.	p. ch.	%	*Hd+Ad* Tot.	p. ch.	%	Hum./Anim.
Br.-Ind.	128	6.7	20.7	283	15.0	46.0	89	4.7	14.5	48	2.5	7.8	1:2.2
End.	131	7.0	15.5	444	23.3	52.5	85	4.5	10.0	41	2.2	4.8	1:3.4
p (Chi-Squ.)			<.01			.02			<.01			<.02	

f. Human and Animal Responses; First Three Reactions

	Sum Hum. Tot.	p. ch.	%	Sum Anim. Tot.	p. ch.	%	Hum./Anim.
Br.-In.	98	5.2	21.5	220	11.6	48.2	1:2.2
End.	84	4.4	17.9	297	15.6	63.3	1:3.5
p (Chi-Squ.)			>.05			<.01	

(*c*) Artificial likenesses or objects made from animal parts, such as fur, animal rug (*AObj.*)

Object

(*a*) Objects of daily use, such as furniture, ashtray, pen (*Ou*)
(*b*) Technical objects, such as cars, radio, airplane (*Ot*)
(*c*) Objects attached to a person, such as clothing, hairpin, tie (*Op*)

Table 10 represents the distribution of the various categories for each group. These are the main results: (*a*) The brain-injured group produced a higher total percentage of human concepts than did the endogenous group. (*b*) Endogenous children, on the other hand, gave more animal responses than the brain-injured. These two differences were statistically significant, according to Chi-Square analysis, at the one, and two per cent level, respectively (Table 10*e*).

The relation of human to animal responses is a significant ratio in Rorschach's evaluation. This is due to the fact that responses referring to animal forms are easily made; they are more trivial than ony other type of responses. This ratio between the percentage of human and animal responses signifies the difference between the two groups most clearly. The ratio for the brain-injured group is 1:2,2, for the endogenous group 1:3.4.

Since animal responses are the most obvious, one could contend that the higher frequency of *A*-responses in the endogenous group was simply the consequence of the larger total number of answers given by these children; the more responses are produced—it could be argued—the less particular will the subject be in the selection of appropriate concepts. As before, the validity of this conclusion was tested by basing the calculations only on the first three answers to each card by each subject. Table 10*f* shows that such calculations did not considerably alter the results. The percentage of human and animal responses was slightly higher, but the relation between both types of responses remained almost the same for each group. It can therefore be concluded that the higher percentage of animal responses given by endogenous children is not the consequence of a larger amount of reactions. (*c*) Piece-like parts of human and animal bodies were more frequently seen by brain-injured than by endogenous children. The sum of these responses ($Hd+Ad$) amounted to 7.8 per cent of the total number of interpretations given by brain-injured children against 4.8 per cent produced by the endogenous group. This difference is significant at the two per cent level, according to Chi-Square analysis. (*d*) Interpretations referring to objects were a larger percentage of the total in the brain-injured group. The difference in object responses was significant at the one per cent level,

according to Chi-Square analysis. (*e*) Among the various types of object responses those referring to a person's belongings (*Op*) clearly differentiated between the two groups. Endogenous children had very few *Op* responses (.9 per cent), brain-injured produced considerably more (4.7 per cent). This difference is significant at the one per cent level, according to Chi-Square analysis (Table 10*c*).

Among the *miscellaneous contents of minor importance* only the interpretations in terms of geographical forms differentiated between the two groups. It is interesting to note that the greater amount of geographical interpretations given by the endogenous children was due to the fact that they saw maps more often; forms such as peninsulas, islands, oceans, etc., were almost equally frequent in both groups (4.7 and 4.1 per cent respectively).

G. Popular and Original Responses

Rorschach originally classified as *popular*, those responses occurring in a normal population with a frequency of at least once in three records. Other interpreters suggested different frequencies. We have again employed the standards of scoring computed in M. Hertz's frequency tables. Table 11 shows, that though endogenous children gave more popular responses, the difference in terms of percentages of the total number of interpretations was small and statistically not significant.

The term "*original response*" applies to those interpretations which do not occur more than once in a hundred records. The term "original" is somewhat misleading; it includes responses which are rare because of a fantastic or bizarre manner of conception not warranted by the configuration of the blot area. These original answers are scored $O-$; they are distinguished from $O+$ responses which are keen and unusual interpretations, showing originality in its specifically restricted sense. The tabulation of $O+$ and $O-$ responses by Hertz have guided us in the scoring of our material. A number of responses unquestionably falling under Rorschach's category *original* could not be found in M. Hertz's tables. They appear in Table 11 under the symbol $O-_x$, since they were almost entirely of the $O-$ type. The few $O+_x$ answers have been omitted.

Brain-injured children gave by far more original responses than did the endogenous subjects, since 14.7 per cent of all interpretations produced by the brain-injured group were original against the 4.1 per cent given by the endogenous group. This is a statistically highly significant difference. An inspection of the table in regard to the two types of original responses

TABLE 11

POPULAR AND ORIGINAL RESPONSES

	P			*O*+			*O*—			*O*—$_x$			Sum *O*—		
	Tot.	p. ch.	%	Tot.	p. ch.	%	Tot.	p. ch.	%	Tot.	p. ch.	%	Tot.	p. ch.	%
Br.-Ind.	81	4.3	13.1	16	.8	2.6	34	1.8	5.5	40	2.2	6.6	74	4.0	12.1
End.	126	6.6	14.8	17	.9	2.0	5	.3	.6	13	.7	1.5	18	1.0	2.1
p (Chi-Squ.)			$>.05$			$>.05$			$<.01$			$<.01$			$<.01$

reveals that this difference is mainly due to the discrepancy in the minus responses. Though the brain-injured group gave, in percentages, somewhat more O plus interpretations, the difference was slight and statistically not significant. On the other hand, the difference in the number of $O-$ and $O-_x$ answers was very considerable indeed. About 12 per cent of all responses of the brain-injured children, but only 2 per cent of those of the endogenous children, could be classified as far fetched and bizarre.

III. INTERPRETATION OF THE RESULTS

There are three groups of investigations to which reference will be made in our attempt to interpret the results of the present study. The first group includes the previous work on the psychopathology of the mentally deficient brain-injured child conducted at the Wayne County Training School. As stated in the beginning, the present study is part of a series of experiments which attempt to differentiate psychologically between the endogenous and the exogenous (brain-injured) type of subnormality. Since this is an experiment on perceptual behavior, the results from the previous studies in the field of perception and concept formation should throw light on the interpretations of the differences found on the ink-blot test.

The second group consists of investigations in which the Rorschach method had been applied to the analysis of adult patients suffering from brain-injury. Oberholzer (13), Piotrowski (14), Harrower-Erickson (6*a*), and Nadel (12) have found certain behavior characteristics of such patients on the ink-blot test which shall be advantageously referred to in our discussion.

Lastly, we shall discuss some of our findings in the light of Rorschach's interpretation of the responses as diagnostic of personality traits.

A. Number of Responses

As may be recalled, brain-injured children produced fewer responses than the children of the endogenous type. The results are parallel to findings in brain-injured adults. Piotrowski, working with 18 patients with various types of brain lesions found the number of interpretations given by these patients considerably less than the average for the normal adult. Harrower-Erickson, in a study of patients with cerebral tumors confirmed, in general, these findings. The agreement in the results gained from brain-injured adults and children does not pertain to the absolute number of responses; there were more responses given by both groups of children than by the brain-injured and normal adults. The significant fact, however, is that there is a similar relationship between the number of responses of brain-injured and non-brain-injured adults on one side, and between that of brain-injured and non-brain-injured children on the other. That is, in both groups of experiments the brain-injured individuals had a restricted output in regard to the controls.

How can these differences be explained? Some observers suggested (2, p. 194) that the restricted output by brain-injured individuals might be due to a lack in the formation of associations. Already, Rorschach had rejected such an explanation. According to him, the number of responses depends

less on associative than on emotional factors. Moreover, results obtained in previous experiments with groups of brain-injured and non-brain-injured children clearly contradict that explanation. Several of those tests consisted of small toy objects which the child was requested to group. The brain-injured subjects saw more relationships between the objects and, accordingly, made more groupings than did the endogenous children. A further test, the picture-object test, consisted of two pictures (representing a boy about to be drowned and a building on fire) and 86 small toy objects. The child's task was to put before each of the two pictures those objects which he thought belonged to them. Here again, the brain-injured child saw more relationships between object and picture, and therefore put more objects before the two scenes. The behavior of the brain-injured child lead us to conclude that one of the characteristics is an "excessive fluidity of association which makes his performance appear erratic—lacking control and discipline" (28).

The seemingly contradictory results of these tests and the ink-blot test in regard to number of responses reveals one of several paradoxical behavior traits characteristic of a brain-injured organism. In certain situations, like that provided by the picture-object test, there is an abnormal flow of associations; in another situation, such as presented by the ink-blots, there seems to be much sluggishness of response. It is possible that this contradictory behavior has a common cause, viz., the lack of intellectual control, of taking a deliberate point of view.[6] This lack may assert itself either in a disinhibition of association which makes it easy for the child to form relationships between objects however far fetched they may be. On the other hand, the deficiency in deliberately choosing a point of view may appear as an inability to shift from one aspect of the situation to another. The inability to shift becomes apparent in tasks where the same material has to be interpreted in different ways. Once having formed one interpretation of an ink-blot the brain-injured child is less able to reorganize the material than the non-brain-injured child. A few observations and experiments may be mentioned which show this pathological trait of "*fixation*" under widely varying conditions.

Since ink-blots are what is called in psychology, ambiguous configurations, two experiments dealing with ambiguous figures may be cited. M. R. Harrower (6) presented Rubin's figure, a drawing which can be either seen as a human profile or a vase, to 30 normals and 30 patients with cerebral

[6]"Abstract behavior" in the sense of K. Goldstein (4, 5).

lesions. She introduced, subsequently, modifications of the drawing which strengthened the outline either of the vase or the profile. Both groups were first shown the original ambiguous figure. If this were perceived as a vase, three modifications were presented, one after the other, each successive drawing increasing the strength and definiteness of the human profile, and vice versa. Whereas the normal subjects changed easily to the interpretation suggested by the modified figure, brain-injured subjects frequently persisted in their first perception, despite the countersuggestion offered by the modified form. If a vase were seen originally by the patient, he still saw a vase despite the configuration enhancing the human profile, and vice versa.

Another experiment dealing with ambiguous figures was carried out by E. Weigl (21). He presented drawings each consisting of two human faces. Each face was drawn upside down with reference to the other; both faces were intertwined in such a way that a turn of 180 degrees resulted normally in a change from the perception of one face to that of the other. Weigl's preliminary results seem to agree with Miss Harrower's findings that brain-injured patients have difficulties in shifting from one perceptual aspect to another.

To sum up, the restricted output of interpretations by brain-injured individuals is probably due neither to associational nor emotional factors, but most likely related to the difficulty in shifting from one to a second or third aspect of a given situation.

B. Whole and Detail Responses

With respect to the blot area, the following significant differences between the two groups were found: Brain-injured children gave, perceptually, more whole responses than endogenous children. They produced more big detail responses of the ordinary type. They also gave more piece-like (oligophrenic) responses. And finally, in contradistinction to the endogenous group, they produced almost no tiny detail responses. Since the differences in the big detail responses are not of the same high significance as the others, we shall restrict our discussion to the results pertaining to whole, tiny detail, and oligophrenic responses.

How should we account for the greater amount of whole responses in brain-injured children? Two kinds of explanations are possible. One can relate these differences either to known behavior trends of the brain-injured organism, or attempt to apply the traditional interpretation of personality, following Rorschach and his successors.

An interpretation with reference to behavior characteristics of brain-

injured individuals may first take cognizance of work with brain-injured adults. M. Harrower-Erickson (6*a*) found that patients with cerebral lesions gave responses too heavily weighted with whole answers.

One meets here, again, with seemingly contradictory behavior traits in brain-injured individuals. On the one hand, brain-injured children gave more whole responses, on the other they excelled in piece-like interpretations. As to an explanation of the greater amount of whole responses in the brain-injured group, we may refer to a frequently observed trend in these children, namely, the trend toward perfection, completeness, exaggerated order. The brain-injured child took the task more literally and often more seriously than the endogenous children. They were less inclined to see in the test a play with forms; they were much more often apologetic than the endogenous children, if the form did not completely fit the object they had in mind; they would say: "This is an elephant, but not one like I saw in the zoo; an elephant you do not find around here; I never saw one like this before." "This is the back for a bed but no legs are on it yet."

It is in accordance with this pedantic trend, that many brain-injured children tried hard to include all of the blot area into the interpretation; they expressed their regret if they did not succeed. "This is a bat, but I do not know what these dots mean," a child would say. Or: "This is an animal skin—except these lines; they should not be there!"

We have observed the pedantic tendency toward completeness in previous tests (19). For instance, in a test where the subject is requested to group objects together, brain-injured children may refuse to group together a card with the printed name "ball," and a small ping-pong ball, because the ball was slightly dented. Similarly, in a test dealing with animistic attitudes, we found that brain-injured children are particularly sensitive regarding completeness of things. In comparison with endogenous children their reasoning is more often centered around the wholeness of objects. A brain-injured child argues, for instance, as follows: A chair is living "cause nothing broke off" (24).

It is probable that the predominance of whole responses found in brain-injured children is related to the trend toward perfection. Such an explanation would agree with our observation that brain-injured children start more often with a whole response than endogenous children and convey a certain reluctance to shift from there to a part of the dot pattern. Forty-three per cent of the first responses of the brain-injured to each of the 10 cards were whole responses; endogenous children gave only 30 per cent

whole responses initially. Moreover, brain-injured children continued with the aspect of the whole more frequently than the endogenous group.

It has been contended (4, 19) that the pedantic trend toward perfection is a compensatory reaction to the brain-injured organism's dissociative tendencies. The hypothesis of such compensatory relationship between dissociation and pedantry would explain the seemingly contradictory behavior of brain-injured children on the test, shown by the great number of whole responses side by side with the *relative high amount of piece-like or oligophrenic responses.*

The reaction to dissociated elements of a normally well-integrated situation is highly characteristic of the brain-injured individual. For example, on the picture-object test described above, the brain-injured child frequently placed objects before the picture in "clusters." These clusters consisted of various objects which were closely interrelated but much less related to the main situation. To illustrate, a child occupied himself by building up a garden before the drowning-boy picture, placing a man with a wheelcart into the scenery and surrounding him with all sorts of garden tools, sand, trees, stones, etc., becoming almost oblivious to the main problems at hand. This arrangement in isolated or self-dependent units were rarely, if ever, found with the endogenous children. The piece-like organization on the picture-object test seems related to the oligophrenic detail response in the ink-blot test, just as the frequently observed reluctance to discard any object presented on the object-picture test appears akin to the tendency of the brain-injured child to utilize as far as possible the whole area of the ink-blot.

The results throw light on the question of whether or not so-called oligophrenic details are a characteristic part of the records of the feebleminded. Rorschach termed the response "oligophrenic" because he assumed that it occurred frequently with mentally deficient individuals. Subsequently some observers confirmed, other refuted this assumption. Our study suggests that this contradiction of opinion can be reconciled on the basis of a differentiation between two types of feeblemindedness. The oligophrenic response seems to be a sign of brain-injury rather than a characteristic of feeblemindedness proper. Non-brain-injured mentally deficient children did not show signs of disintegration in various sensori-motor and conceptual tests. That they gave very few of the piece-like interpretations, is in agreement with their behavior in these previous experiments.

Tiny detail responses, in contradistinction to oligophrenic responses, were abundant in the records of endogenous children, and practically absent in the brain-injured group. An interpretation of these facts cannot be at-

tempted from the point of view of brain-injury since the brain-injured children behaved here like normals who also usually give very few tiny detail answers. Our results suggest that this type of response is caused by trends present in generally feebleminded, rather than brain-injured subjects. To interpret a speck as "men" or "horses," etc., as endogenous children did, shows, not only a lack of autocriticism, but probably also of creative power and imagination. We venture, therefore, the suggestion that endogenous and brain-injured children display opposite trends of imaginative behavior on the ink-blot test. Whereas brain-injured children, as we shall discuss in more detail later on, show undisciplined, uninhibited fantasy, endogenous children are "dull," i.e., poor and restricted in imaginative activity.

However, we should mention an apparent disagreement between the behavior of brain-injured children on the ink-blot test and on previous tests of concept formation. The brain-injured children, confronted with the task of sorting various objects, tended to base the grouping on quite unessential or accidental details of these objects. It is also known from general and clinical experience that brain-injured individuals are easily attracted by small details in the environment, details which usually escape the attention of non-brain-injured individuals. Why then, are brain-injured children not attracted by the small details of the ink-blots? This contradiction to their behavior on the sorting tests, we believe, is only superficial. If the responses of the brain-injured children on the sorting tests are analyzed more profoundly, it will be found that the sensitivity to small details can hardly be called an independent behavior characteristic. Whether or not brain-injured individuals will be abnormally attentive to small details, will depend on a particular situation and on the arousal of deep-set behavior trends inherent in brain-injured organisms. Such trends are: "a forced responsiveness to stimuli"; "pathological fixation" and "perseveration," i.e., the inability to shift from one perception, once formed, to another; dissociation, i.e., disintegration of the whole into relatively self-dependent elements, and so on. One example may serve as an illustration. A brain-injured child, contrary to normal grouping, places together a card labelled "ball" and a picture of a bell. The child's explanation was that "there is a ball in the bell" meaning the little pellet on the free end of the clapper. Probably all three behavior trends mentioned above, are effective in the choice of this small and quite unessential detail. In the first place, any stimulus, because of outer or inner reasons may catch the attention of the child (*"forced responsiveness"*); once the stimulus has come to his attention, it is difficult for the child to discard it (*"fixation"*).

The main reason for the effectiveness of the pellet as stimulus, lies probably in the rigid mental set (*perseveration*); instigated to look for a ball, any suitable object, due to perseverative tendencies, may become a ball. Such a process may be facilitated by *dissociative* trends; the pellet can be severed from the bell and seen as a self-dependent unit by an individual whose perceptions show the mark of disintegration. As this example illustrates, it depends on the peculiar interaction of various pathological trends in a specific situation to make brain-injured individuals excel in responses to insignificant details.

The tiny details—specks, dots, very small protrusions—are in no way comparable to the details of meaningful objects encountered in the sorting tests. In general, one would not expect these small elements to particularly attract the attention of the brain-injured child; they have neither the sensory intensity nor the shape which could be filled with meaning according to a preconceived mental set. Nor does the task, in contradistinction to the sorting tests, favor such mental sets.

To repeat, the only detail responses characteristic for our brain-injured children, and explainable in the light of behavior observed in previous studies, are the piece-like or oligophrenic responses. Here, the shape of the blots may suggest parts of the human or animal body which a dissociated mentality can easily accept as a satisfactory solution.

Before leaving this discussion we wish to comment on the results in regard to Rorschach's interpretation of subnormal intelligence. The proportions of whole and various detail responses are a significant feature in Rorschach's diagnosis. The quantitative relationship of whole- and detail-responses in a normal record amounts in average to about 1:3.3. A deviation from this norm in favor of detail answers, is generally considered to be related to intellectual subnormality. It is in agreement with such an interpretation that the ratio for the feebleminded children of the endogenous type was 1:5.7; this is a ratio considerably below the norm. The ratio for the brain-injured group, however, was 1:3.7; this is a proportion which closely approximates that of a normal group. To be sure, Rorschach and his followers were not aware of the two types of mental deficiency and therefore assumed uniform signs of subnormality. If one is inclined to disregard our interpretation of the greater amount of whole responses in the brain-injured children, in terms of certain peculiarities of their behavior, an alternative explanation might be suggested on the basis of Rorschach's findings. The belief has been variously expressed that brain-injured mentally subnormal children have more intellectual power than their performance

on routine intelligence tests would indicate. The relatively high ratio between whole and detail responses could then be interpreted as such a sign of higher intellectual status. In this connection one could also point out the numerous tiny detail responses, as signs of intellectual defect of the endogenous group, which is not present in the records of the brain-injured group. We shall return to this problem of the intellectual status of brain-injured children in later sections of the discussion.

C. White Space Responses

Responses which utilized the white spaces differentiated significantly between the two groups. The percentage of white space responses was more than twice as high with the brain-injured group in comparison to the non-brain-injured group.

As mentioned earlier, many of these responses are reversals of the configurational relationship between figure and background; contrary to the usual perceptual organization, the white part, ordinarily perceived as neutral background, is seen as figure, the black and grey parts, normally selected as figure, form the surrounding.

Earlier experiments have shown similar abnormalities of the figure-background relationship in brain-injured mentally deficient children. Several tests may be mentioned, devised by Werner and Strauss (27) for the purpose of differentiating between normal and abnormal figure-ground reactions. One test consisted of a series of pictures. These pictures were black and white line-drawings of objects such as a hat, a boat, a bird, etc.; they were embedded in clearly structured homogeneous backgrounds consisting of jagged or wavy lines, squares, crosses, etc. The pictures were exposed for one-fifth of a second and the child requested to tell what he saw. The endogenous children saw the object predominantly, without mentioning the background. The brain-injured children very frequently saw only the background. In another, a tactual-motor test, the child was asked to recognize three figures by touch only; these figures were a square, an oval, and a triangle. The forms were presented on two sets of boards. In the first set the background was composed of rows of flat, enamelled thumb tacks; the figure, formed by semipherical tacks, rose 5 mm. above the structured ground. In the second set the background was a smooth surface and the figure consisted of a raised wooden solid. The board was shielded from the child's sight by a screen; after exploring the surface with his fingers the child was asked to make a drawing of what he perceived. Whereas no differences were found for Set II, the drawings of the forms of Set I differentiated signifi-

cantly between the two groups. The endogenous children grasped the figure easily, whereas the brain-injured children were particularly attracted by the single tacks. Accordingly, the endogenous children made line drawings whereas the brain-injured very frequently drew small circles representing the background alone, or the figure with the background. The strong reaction of the brain-injured group to the white spaces of the Rorschach patterns is in agreement with the results of these previous experiments. The abnormal reactions can be understood from the known facts that the brain-injured organism is much more at the mercy of the external sensory forces than the normal organism. The attention of such a person tends to be caught more rigidly by stimuli which, by their largeness, their brightness, etc., are quantitatively conspicuous.

D. The Movement Responses

In contradistinction to the endogenous group, the brain-injured children infrequently projected movement into the ink-blots. Moreover these so-called kinaesthetic responses were much more often of the static type, describing posture, than the responses of the non-brain-injured group who, in turn, more frequently perceived action. A comparison of these results with previous studies on normal children cannot attain high validity because of the subjectivity in the judgment of movement responses by the various investigators. The most recent work, that by M. Hertz (9) shows an average M number of 3.7 and a percentage of 11.7 for 15-year-old boys. In her earlier study (8) she obtained an average of 2.9 and a percentage of 9.1. Using her definition of scoring M response (i.e., human-movement + humanlike animal-movement) our score of M for the brain-injured group would be 1.2 (3.7 per cent), and for the endogenous group 2.3 (5.1 per cent). In comparison with these normal groups the M responses appear smaller in the endogenous group but lag far behind in the brain-injured group. A similar relationship was obtained when M and FM responses were counted together. The average number of $M+FM$ responses is 6.8 (20.6 per cent) for the normal 15-year-old boys, 5.3 (12.1 per cent) for the endogenous, and 2.2 (6.5 per cent) for the brain-injured. The results concerning the relatively small number of kinaesthetic or movement responses of brain-injured children generally agree with the findings by Piotrowski on brain-injured adults. This author contends that restriction in the number of movement responses is one of the Rorschach signs of brain damage.

Our findings may appear paradoxic to many who are acquainted with the hyperactive, kinaesthetically highly stimulated behavior of brain-injured

children. In view of their hyperactivity in daily life one might, at first thought, expect not a smaller, but a greater number of movement responses in comparison with endogenous children. We shall attempt to solve the paradox by referring to the results of previous experiments by Werner and Thuma (29) on visually perceived (stroboscopic or kinematographic) movements. In these experiments children of both types of mental deficiency were presented with two stimuli briefly exposed in rapid succession. In one experiment the first stimulus figure consisted of a vertical, the second of a horizontal line. Endogenous children had for the most part no difficulty in seeing an angular movement of a line going from the vertical into a horizontal position. On the other hand, the brain-injured children frequently saw no movement, but only two lines, one vertical, the other horizontal, in succession.

Werner and Thuma (29, 30) explained the lack of movement perception on the basis of a deficiency in integration. A defect of integrating elements into wholes is a pathological symptom which previous experiments have shown to be present in brain-injured children in their sensori-motor, and perceptual activity, and in processes of association. Apparent movement vision comes about by the integration of the two successive stimuli into one event. The deficiency of integrative power of brain-injured children impedes this unification in time.

We may attempt an even broader interpretation which will link more closely the lack of apparent motion and the restriction of movement responses to the ink-blots. Werner and Zietz (22) have shown, in a series of experiments, that apparent motion is not an entirely visual affair. Body activity, such as rhythmic movement of arms or trunk strongly influence the manner in which successive optic stimuli are perceived as motion. These results lead to the conclusion that movement perception is a dynamic process in which visual and kinaesthetic (tonus) activity are interrelated. One may therefore assume that the deficiency in apparent motion vision of brain-injured children is due to a lack of integration between sensory and body activity. This assumption would also explain another experiment performed by Werner and Thuma. Here, a drawing of an object suggesting movement (for instance a man walking), was presented to the two groups in brief exposure. Endogenous children frequently perceived the object in actual motion, whereas brain-injured children seldom saw more than the momentary position of the object. Such a general syndrome, then, probably links the defects of brain-injured children in visuo-motor performance, in apparent movement vision, and in vision of still pictures representing

motion, with the relative lack of movement perception on the ink-blot test. Whenever interaction of visual and bodily functions is disturbed one may expect an impairment of visuo-motor gestalt formation, of the projection of kinaesthesis into the visual field, etc.

After having thus discussed the various experimental facts in relation to results of the ink-blot test we may finally attempt to interpret the seeming paradox of motor disinhibition present in brain-injured children side by side with a lack of movement perception.

There is general agreement in the assumption that the hyperactivity of the brain-injured child is due to a lack of control on the part of higher centers of the neurophysiological system. An organism, defective in controlling motor energy, can also be expected to be unable to channelize or to "sublimate" this energy by projecting it into the visual field. Impairment of motion perception and hyperactivity do not contradict one another; on the contrary, they are probably the result of the same basic disturbance.

It is interesting to note that Rorschach, in his original discussion of movement responses, has given an interpretation closely related to our point of view. Rorschach states this problem as follows:

> The motility generally observed in a subject is not a measure of the kinaesthetic sensations which arise in him by interpreting a figure. On the contrary, the individual who is influenced by kinaesthetic factors in the test is stable in his general motility, the agile (i.e., motorically less stable) person is the one who is lacking in kinaesthetic reactions to the figures. These are clinical findings of the test which, though verifiable at any time, are still in need of theoretical explanation (15, p. 25).

Rorschach's keen sense for clinical observation lead him to the clearcut statement of the inverse relationship between general motility and movement responses. His peculiar atomistic psychology of perception, however, assuming that seen movement consists of two separate processes, visual and kinaesthetic in nature, must necessarily obstruct the attempt to reach a satisfactory interpretation of these observations.

By conceiving of movement perception as a dynamic process of interaction of visual and kinaesthetic factors, one may readily understand the inverse relationship in terms of integrative activity of the organism. The motorically stable individual appears, then, as one whose motility is highly controlled, channelized, and sublimated through integration with higher mental, particularly perceptual, activity. The energies of a motorically unstable individual cannot be consummated to the same degree in such integrative action.

E. Color Responses

The brain-injured children obtained a significantly higher color score than did the endogenous group. The strong reaction to chromatic colors by brain-injured children is in accord with our clinical experience. The high stimulus value which color possesses for these individuals is being utilized in special educational methods for brain-injured children (26).

It may also be noted that Piotrowski (14) found an abnormal frequency and distribution of color responses in brain-injured adults. His patients gave significantly more color responses than a normal control group. Moreover, the distribution of form-color and color-form responses found in normal records were reversed in the brain-injured patients: interpretations determined mainly by color (*CF* and *C* responses) were infrequent with normals, and consequently, *FC* responses exceeded *CF* and *C* responses considerably; in the brain-injured adults, the number of form-color responses was smaller than the color-form responses. Finally, the patients exhibited one further "organic" sign, not found in normals, viz., the explicit naming of bright colors.

A simple explanation of these facts can be reached by reference to the peculiar sensitivity of the brain-injured organism to sensory stimulation. That bright colors have a strong primitive appeal is known from observations and experiments on young children (22, p. 234). We may therefore expect an organism, abnormally sensitive to sensory stimulation, to be particularly attracted by the bright colors appearing within a rather dull and colorless pattern.

A more profound interpretation of the causes of the color predominance in the brain-injured children might be attempted with reference to experiments conducted for theoretical reasons with sound subjects and dealing with the problem of the total reaction of the organism to sensory stimuli. Werner and Zietz, and R. B. Cattell (22) demonstrated that in states of mind in which the natural objectifying attitude toward the world is receding, the subject experiences strong somatic effects of these stimuli, varying with quality and intensity. Under normal conditions, such bodily reactions are for the most part inhibited; but one should expect that these total reactions to sensory stimulation should be greatly enhanced in an organism lacking inhibitory mechanisms. Actually, Goldstein and his collaborators demonstrated (4, p. 263) that simultaneous with sensory stimulation, a great variety of somatic events are easily observable in brain-injured patients. These authors particularly investigated the relation between optical or tactile sensations and muscle tensions.

A patient (preferably a cerebellar patient) with his arms raised forward, will react to bright colors of various hues by a specific change of the position of the arms. Green color makes the arms move together, red makes them spread apart. These experiments confirm the assumption that brain-injured individuals whose affective-motor system is labile are likely to respond strongly to the stimulation by bright colors.

The general conceptions by Rorschach and his followers agree rather well with the interpretation just presented. Klopfer, for instance, expresses the view that color responses seem to reflect the individual's responsiveness to stimuli from without. "The formulation '*responsiveness to stimuli from without*' represents not only the general readiness of the subject to establish a relationship with the world around him, but it seems to involve more specifically the emotional qualities of this relationship" (10, p. 205).

In brief, color responses are indicative of the affective-motor reactivity of the subject. The predominance of color responses in the brain-injured group is therefore explainable, in agreement with the interpretation given above, on the basis of lack of control of affective-motor energy. Klopfer, in further discussing the significance of the various types of color responses, remarks as follows:

> One way of controlling one's impulses in emotional contacts with the outer world is an attempt to channelize them into proper forms of expression. . . . In the Rorschach situation this attitude seems to be expressed in a tendency on the part of the subject to use the color elements which he finds in the cards, but to incorporate them into a concept which at the same time takes into consideration the given form elements. The *FC* response is, therefore, the principal element of such an outer control (10, p. 226).

The relation between these *FC* responses and the responses in which color dominates (*CF* and *C* responses) reflects therefore this power of controlling one's own impulses. It has been found that sufficient amount of control is indicated if the number of *FC* reactions equals or exceeds the sum of *CF* and *C* responses. As Table 12 shows, this condition for sufficient outer con-

TABLE 12

DIFFERENCE *FC*—(*CF* + *C*)

	p. child	%
Br.-In.	1.6 — 1.8 = — .2	5.0 — 5.5 = — .5
End.	2.1 — 1.0 = +1.1	4.7 — 2.2 = +2.5
Norm. (Hertz)	2.1 — 1.4 = + .7	6.5 — 4.1 = +2.4

trol is fulfilled by the endogenous group. The two groups differ widely with respect to the difference $FC - (CF + C)$.

For sake of comparison, the figures for normal 15-year-old boys taken from Hertz' studies have been added. They show that endogenous children were close to normal performance. Our interpretation is supported by the fact that crude color responses (C) as a sign of uninhibited impulsiveness, practically never occurred with the endogenous group but were quite noticeable with the brain-injured children.

A further indicator of the degree of control is the relation between movement and color responses. If the lack of movement responses reflects the failure of the organism to channelize motor-affective energy into visual

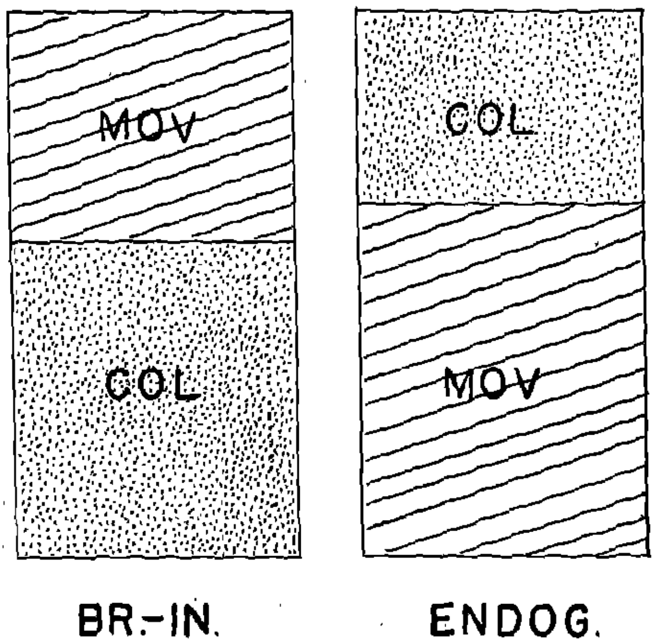

FIGURE 1

DIAGRAM SHOWING INVERSION OF COLOR-MOVEMENT RELATIONSHIP IN BRAIN-INJURED VERSUS ENDOGENOUS CHILDREN

imagery an inverse relationship of movement and color responses between the two groups should be expected. As Figure 1 shows, the proportion

ΣMov:ΣCol[7] for the brain-injured is 74:100, and for the endogenous group 100:53.

The significance of the ratio *M:Color* score as a sign of the power of outer control has been discussed at length by Klopfer and Kelley. According to these authors, the more C_{sum} (color score) exceeds M, the more likely it is that the balance of outer control is disturbed.[8] "Where *sum C* exceeds twice the number of M . . . color responses must be very well balanced within themselves to guarantee the necessary amount of outer control" (10, p. 230). Brain-injured children gave 17 M responses; their color score was 56.5. Endogenous children gave 29 M responses and their C_{sum} was 39.5. In other words, C_{sum} exceeded the number of M more than three times in brain-injured children, whereas, with the endogenous group C_{sum} and M responses were more evenly distributed. The general conclusions are not altered if the M responses are scored in the traditional way by including the human-like animal movement (MFM) responses. The ratio *M:Color* score for the brain-injured children is then 22:56.5, for the endogenous group 44:39.5.

F. Form Responses

The following results may serve as a basis for discussion: (*a*) The total number of form responses was relatively high with both types of children; it did not differentiate significantly between the groups. (*b*) Brain-injured children produced significantly more good form responses, endogenous children more poor form responses. Accordingly, the so-called F plus percentage was higher with the brain-injured group.

Both groups gave about 75 per cent form responses. Rorschach interpreters consider 20 to 50 per cent form answers as characteristic for the normal record. According to Klopfer and Kelly, a form percentage between 50 and 80 invariably corresponds to signs of inflexibility; form percentages above 80, as a rule, are found only in pathological cases (10, p. 234). The interpretation of a high percentage of form responses as being related to an abnormal degree of inflexibility agrees with the fact that rigidity is known to be an outstanding trait of mentally deficient children. That both groups are not differentiated with respect to this behavior on the Rorschach test does not, however, mean that rigidity is a unitary trait identical in both

[7]In order to avoid confusion, the unweighted sum of color responses is designated here as Σ *Col* whereas Rorschach's term C_{sum} (weighted color sum) appears in our tables as "Color Score."

[8]By outer control these authors mean the control of one's impulses in contacts with the outer world.

groups. As we shall discuss later,[9] the causes and the form of rigidity are partly different in the two types of mental deficiency. It is probably because of the special arrangement of the Rorschach situation, that differences of rigidity cannot be as clearly distinguished as by means of specially devised tests.

The higher percentage of plus-form responses found in brain-injured children is, in the first place, interesting with reference to the problem of perceptual deficiency. In previous tests, such as our figure-background test and the marble-board construction test, deficiencies in visual and visuo-motor organization have been found with these children. The question has arisen whether these disturbances are not due simply to a functional defect of perception per se, and not to general dynamic factors. Werner and Strauss (25), using a test dealing with visual form abstraction, did not find differences in visual perception between the groups. The fact that, on the Rorschach test, brain-injured children have a higher percentage of plus-form responses supports the view that deficiency of the perceptual functions as such, cannot be considered to be responsible for the various disturbances, found in tasks which involve these perceptual functions. In order to account for the higher plus-form percentage in brain-injured children one may refer to the difference in the attitude of the two groups toward the test situation. We have already mentioned before that brain-injured children took the task, in general, more literally, and more seriously than the endogenous children, that they expressed more often dissatisfaction about the discrepancy between the blots and their own interpretations. In other words, they frequently displayed pedantic and critical behavior whereas endogenous children showed less concern about their interpretations. Brain-injured children seldom interpreted, for instance, a tiny spot by a vague concept; as we have seen, such minus-form responses are frequent among endogenous children.[10]

This explanation of the relatively high amount of plus-form responses among brain-injured children seems to agree quite well with Rorschach's observations. He found that the subjects, such as pedants, who were most conscious of their effort in interpretating the blots were among those who produced a high plus-form per cent. Rorschach thus definitely relates the perception of plus-form to pedantic behavior (15, p. 17, 23).

[9]Cf. discussion on perseveration.

[10]To be sure, a pedantic attitude may lead to the observation of the tiny spots, as it frequently actually does with adults in whom pedantry appears combined with restricted power of imagination. Such a person will, however, probably never interpret these tiny bits as men, horses, and the like, as endogenous children do.

Consideration might be finally given to still another explanation, based on the relation between the plus-form per cent and degree of intelligence. According to the original statistics by Rorschach, less than 80 per cent of plus-form answers, is a sign of limited intelligence. Borderline cases produce roughly an $F+\%$ from 60 to 70, and morons between 50 to 60 per cent plus-form responses. According to these statistics, the endogenous children would fall within the limits of the borderline group whereas the brain-injured children would be classified significantly above that level. If one disregards the before-mentioned explanation in terms of pedantic and critical attitudes, a possible interpretation might th be that the brain-injured children, though of the same mental age level as measured by a Binet test, actually function on a superior level, in comparison with the endogenous children.

G. Content of the Responses

Brain-injured children gave more responses containing human figures .nd objects. The records of the endogenous group, on the other hand, contained more animal forms. Moreover, brain-injured children more often saw parts of human and animal bodies than the endogenous children.

That the brain-injured children produced a significantly greater number of *human concepts* is definitely related to the behavior of these children in previous experiments.

We first wish to quote from a study by Werner and Carrison (24) concerning the animistic thinking of the two groups of mentally subnormal children. In these experiments the children were asked whether or not inanimate objects (such as a stone or a knife), natural forms and events (such as clouds, wind), animals and plants, were alive. The children were further questioned about the reasons for each judgment. The brain-injured children employed more frequently than the endogenous children the following two criteria for being alive: (a) The c iterion of usability for human purposes; (*b*) the criterion of human behavior, such as talking and thinking. Whereas the endogenous children predominantly reasoned in terms of general biological activity (viz., spontaneity of action), the brain-injured children tended to refer particularly to human activity. Aside from employing human behavior as a criterion for life, brain-injured children were, in general, much more prone to discuss human situations in their responses, even if such reasoning appeared rather out of turn. A brain-injured child would argue, for instance, that a bird is living because "he flys around, eats, and does everything like we do. We don't fly, but try to anyway and break our

necks." Thus, it appears that the frame of reference in the reasoning of the brain-injured compared to endogenous children is, to a much greater degree, that of the human sphere.

This conclusion is supported by observations from various experiments dealing with concept formation, such as the picture-object test. Brain-injured children, contrary to the matter-of-fact attitude of endogenous children, showed a trend toward dramatization in these simple tasks of relating objects to one another; they tended strongly to inject the human element into such groupings.

In seeming contradiction to this conclusion, stands the fact that the brain-injured group produced more responses dealing with objects. A closer inspection of the various forms of object responses, however, reveals that the predominance of object answers of brain-injured children was mainly due to the greater number of interpretations referring to personal belongings, and, to a small degree, to objects of daily use. Thus, the brain-injured children tended to refer to objects of the specific human sphere much more often than the endogenous children; the latter, in turn, excelled in responses of technical objects, that is, objects farther removed from the immediate human activity. As calculated from Table 10, the percentage ratio of the number of objects of personal and daily use to technical objects was 11.7:2.8 for the brain-injured, against 6.2:3.8 for the endogenous group. This generally agrees with everyday observation of these children; it leads to conjecture that compared with endogenous children, persons, relative to factual matter, must have an inordinately high valence in their world.

A further characteristic difference concerns the number of *animal responses*. The animal percentage is one of the most significant items of the traditional Rorschach diagnosis. Its importance is derived from the fact that the ink-blots lend themselves more readily to an interpretation in terms of animals than to a perception of any other form. Therefore, the less a subject is able to choose his concepts outside this most obvious area, the more likely he is to be confined to the obvious, to a narrow sense of interests (10, p. 215). The traditional Rorschach diagnosis would therefore take the responses of the brain-injured children as an indication of richer associations[11] in comparison with endogenous children of the same mental levels. Such an interpretation would agree with our earlier conclusions, drawn from the fact that tiny details were abundant in the responses of the endogenous, but absent

[11]It must, however, be kept in mind that the avoidance of trite responses is partly due to the particular, abnormal trend of brain-injured children toward far-fetched associations.

in the answers of the brain-injured group. This interpretation would also explain the fact that among the miscellaneous contents of minor importance, the naming of maps occurred much more frequently among endogenous children. Naming of maps, vaguely perceived as they were with our children, must be considered answers that are just as trite and stereotyped as animal responses. Finally, the greater number of responses involving parts of human and animal forms given by the brain-injured children agrees with the previously stated finding that oligophrenic details or piece-like perceptions were characteristic for this group. We may, for an explanation, point again to dissociation as a characteristic mental trait of a brain-injured organism.

H. Original Responses

The brain-injured gave a considerably greater number of original responses than endogenous children. This difference was mainly due to the abundance of *O*— responses, that is, far fetched interpretations. It may be noted that Oberholzer found a large number of *O*— responses in cases with traumatic brain-injury (13).

The tendency to produce unusual, strange, and even bizarre ideas is a characteristic pathological trait of many brain-injured children; it has been invariably found in all our previous studies concerning conceptual thinking (19, 24, 28).

On the sorting, the picture-object, and the animism test, responses statistically defined as uncommon were found to be far more frequent among brain-injured than among the members of the endogenous group. This difference was to a great extent due to the tendency of the brain-injured children to single out incidental details, to build up far fetched associations, to transform the meaning of objects according to their present imaginative trend of thought, etc.

A few illustrations may be offered. As it may be recalled, on the multiple choice test the child was requested to choose one of three objects to be grouped with a key object. A brain-injured child may put together a hairpin and a piece of red cloth explaining, "Patch your dress and patch your hair," or a stamp showing the bearded king of Italy and a razor blade, with the words, "Man should have a shave!"

The records of the behavior of brain-injured children on the picture-object test showed the same inclination toward far fetched and fanciful associations. Objects placed before the drowning picture by the brain-injured children, but not by the endogenous children, were: soap ("he washes himself when

he comes out of the water"), fork and spoon ("he eats when he comes out of water") and a ball ("before going into water he had it in his pocket").

In the following, a few examples of the original responses of brain-injured children are given. For the benefit of those who are acquainted with Hertz' Frequency Tables, her topographical symbols for the area of the card involved were included.

Card I:VW(S)

This is Hitler, there is his big mouth" (white part at bottom, 40), "he has four eyes" (7, 6), "a big bump in his head" (3); "there are his ears" (13), "nose" (31) "and his feet" (12). "The feet are pretty much up to his mouth. He is bad."

Card IV:∧W

"A rabbit with wings. If you cut the wings off it's just a rabbit."

Card VI:S+S (lower two-thirds of figure)

"It's a bathroom. There are washroom rods for hanging washings on" (27).

Card VII:(1+1)

"These are dolls' heads from bushes. The bushes have grown up and have been shaped like this."

Card VIII

All red parts (2+5+1+d): "If red would go clear around, would be equator—that's the hot spots of the earth."

1+1: "That's wind blowing—it's shaped like it."

Card X:(9)

"It's a trap for trapping crooks."

Thus, the results indicating a relatively high amount of original responses (mainly of the minus type) given by brain-injured children are in accordance with the findings on the previous tests. There, an excessive fluidity of the associations, a pathological trend for assimilating unrelated material has been found to be characteristic of the performance of the brain-injured children. The relatively great number of *O*-minus responses appears to be another expression of the same impairment of intellectual control.

I. Perseverative Responses

Neurologists, particularly Goldstein (4) have stressed the significance of perseveration as a symptom of pathological behavior of brain-injured adults. In accordance with these clinical findings, Oberholzer, Piotrowski and others observed strong perseverative tendencies in the responses of brain-injured patients on the ink-blot test. Piotrowski regarded perseveration to be present if at least three similar interpretations appeared in the record with little regard

to form (F—). Accepting this criterion, perseverations, though present in most records of our children, were particularly conspicuous only in some subjects. Moreover, the number of perseverations did not differentiate significantly between the two groups. Four and eight-tenths per cent of all the responses of brain-injured children could be classified as perseveration, against 6.3 per cent repetitive responses given by the endogenous group.

The discrepancy between previous work on brain-injured adults and our own study cannot be interpreted in terms of differences in the behavior of undeveloped and mature brain-injured organisms. We daily observe strong perseverative tendencies in brain-injured mentally defective children. Moreover, Strauss and Werner (18) have shown by experimental analysis that situations can be set up which bring to the fore strong perseverations in brain-injured children rarely seen in endogenous subjects. It has to be assumed, therefore, that the reason why perseverations here were not too frequent with most subjects must lie in the relation between the difficulty of the task and the severity of the brain damage.

It is possible that the adult patients, because of their severe brain damage, had much greater difficulty in meeting the task than our relatively slightly injured children; the former would therefore yield more readily to perseverative tendencies than the latter.

Before attempting to further discuss the lack of significant differences between the two groups, a brief reference to the above mentioned experiments on perseveration will be advantageous. One of these experiments consisted of cards containing dot patterns, which were presented for a fraction of a second. After each presentation the child had to draw the pattern. In the first phase of the experiment several patterns very similar in shape were used; each pattern was presented three times. In the second phase of the experiment, dot patterns different from the foregoing and among each other, and more complex, were presented, each card only once. In the first phase, both groups made a large number of perseverations. In the second phase of the experiment, the endogenous children made no perseverations at all, whereas the brain-injured children perseverated in one-fifth of all trials by repeating patterns of the first phase. This experiment suggests that the endogenous children perseverate if the test objects are not strikingly different from each other. All children may therefore perseverate on the basis of a confusion between objects not sufficiently dicrete. However, a brain-injured child will often perseverate even when the test objects are strikingly discrete; he may respond with a drawing which he had made before and which has no similarity whatsoever with the test object.

One is probably justified in assuming that the ink-blot situation, because of the vagueness of the forms presented, resembles the first phase of the perseveration experiment. Therefore, it can be expected that the ink-blots provide opportunity for perseverations for the endogenous children as well as for the brain-injured. The difference of the mental make-up of endogenous and brain-injured children seems to be reflected only in the cases with particularly strong perseverative tendencies. The records of some endogenous children are filled with stereotyped, vague and matter-of-fact concepts; they give the impression that it is the narrow range of association which accounts for a genuine lack of discrimination of form. One child may see pigs, another dogs, a third people, indiscriminately and persistently throughout several trials.

Though such type of repetitive answers were also found with brain-injured children, another kind, which did not occur with the endogenous group, was outstanding in the records of some of the brain-injured individuals with severe perseverative trends. Characteristics of these perseverations were: The concepts involved in repetition, were more specific than those of the endogenous children's records just mentioned; they dealt definitely with imaginative situations; they were obviously related to personal experiences and emotional complexes. In other words, perseverations of this kind appear to be less superficial, more the consequence of a deep-set mental attitude, than repetitive responses of the first kind.

A few examples illustrating the differences between these two forms of perseverations may be added:

Endogenous boy (*MA* 9-2; *IQ* 68)

Card I

<(W) "Mountain, big old cliff."
<(32) "People, going across cliff."
<(34) Wagon, somebody's pulling it, going up the mountain.
V(18) "More people—they are going up here."
>(9) "People, walking over there."

Card II

V(10) "More people, going over a mountain."

>(29) "Some people live in those hills."

Card III

V(1) "Trees on a mountain."

V(6) "Some people live in those caves."

Card IV

>(3) "Small people, on horses."

Card V

∧(15) "Small people, going up the mountain."

Compare these stereotyped responses with perseverations of a brain-injured boy (*MA* 10-2, *IQ* 75) whose feelings of anxiety and frustration are reflected in stories of aggressiveness centering around horse thieves, crooks, traps for animals and men.

Card I

V(W) "A mountain—a horse could step up this side and down the other side without the crooks knowing it—but not this way, 'cause horse wouldn't have a good take-off."

Card II

V(5) "A horse could climb that, couldn't it?"

∧(3) "Some crooks and then some good guys."

∧(20) "A trap for the horse—a horse couldn't come up without stepping in."

Card IV

>(W) "Horses can go on these mountains."

Card V

(W) "Horses could go up these hills—yump-yump-yump and get the crook."

Card VII

∧(1+2) "Two rabbits on side of hill."

∧(12) "Some kind of trap for the rabbit—but rabbit doesn't know it."

Card VIII

∧ (30) "Trap for some crook, man or something—would climb up here and get in trap."

Card X

V (9) "Nice big trap—so if man falls in he can't get out."

IV. COMPARISON OF THE RESPONSES OF BRAIN-INJURED ADULTS AND CHILDREN

The principal results of the work on brain-injured adults, already partly mentioned in this study, may be briefly reviewed. Emil Oberholzer was the first to apply the ink-blot method to organic cases. These are his main conclusions:[12]

1. The patients are unable to synthesize many details into one good interpretation. They are poor in distinguishing the essential parts from those of secondary importance.
2. The patients believe that the ink-blots represent some definite objects which they are supposed to recognize.
3. Their associations are poor and uniform, frequently marked by perseveration. They are not able to develop their associations. Uncontrolled repetitions of some verbal phrase occur.
4. Their reaction time is lengthened.
5. They give a large number of original responses. These responses, however, are of poor quality and inadequate.
6. The relative numbers of responses to whole ink-blots and to parts of them do not differ from those of normal subjects. The succession of whole and part responses also is normal.
7. The patients coöperate well. They are interested in their achievement.
8. The introversive part of their personality diminishes while the extratensive increases. The patients rapidly become self-centered extraverts.

The most comprehensive study of patients with organic disturbances of the central nervous system has been made by Z. Piotrowski. He found a persistent and marked difference between the Rorschach records of 18 cases with involvement of the brain cortex on one side, and of a non-cerebral-organic group (10 cases) and a hysteric group (5 cases) on the other. There were 10 signs which seemed to differentiate the brain-cases from the non-cerebral cases. These are the signs:

1. Number of responses restricted (not more than 15).
2. The average time per single response longer than normal (one minute against three quarters of a minute).
3. Movement responses restricted (not more than one against three *M* responses in normals).
4. Color-naming. Normal subjects give no color denomination at all.
5. Plus-form responses below 70. With normal adults it averages 80.

[12] Summarized after Piotrowski (14).

6. Popular responses below normal (25 per cent against 30 per cent with normals).

7. Perseveration, that is, repetition of the same response to several ink-blots.

8. "Impotence," i.e., a response given under recognition of its inadequacy.

9. "Perplexity," that is, a feeling of incompetence to decide by oneself whether the task has been performed well.

10. Automatic or pet phrases used indiscriminately. Piotrowski suggests that the occurrence of at least five of these signs in a record can be considered as indicating brain-injury. The validity of this conclusion is strengthened if other signs of abnormality, although not specifically cortical, are present.

These additional signs are:

11. An abnormal frequency of color responses (30 per cent against 18 per cent in normals).

12. An abnormal distribution of the various categories of color responses. Normally, the *FC* responses are the most numerous (2-3), whereas only one *CF*, and usually no *C* response is given. In the group with brain-injury *CF* and *C* responses are relatively increased so that all three color categories are almost equally numerous.

Harrower-Erickson (6*a*), mainly studying cases of brain tumor, found the following characteristics: (*a*) Number of responses restricted; (*b*) a proportionately too high amount of *W* responses; (*c*) number of clear precise forms smaller than average; (*d*) percentage of *F* responses higher than normal; (*e*) a poor range of psychic reactivity (*M*: sum *C* barely 1:1), and (*f*) absence of shading (*K* and *FK*) responses.

An evaluation of the present study in the light of the work on brain-injured adults has to consider the difference in the subjects and the scope of these investigations. In the first place, the adult brain-injured patients are probably much more severely disturbed than our children are. Secondly, our study did not aim at a comparison between normals and brain-injured individuals, but between two subnormal groups.

A number of similarities between the results of our study and those of the work on adults, particularly Piotrowski's, may be pointed out. The brain-injured children, in contradistinction to the endogenous group, showed the following signs which are held to be characteristic for brain-injured adults: (*a*) Number of responses restricted; (*b*) average time per single response longer; (*c*) movement responses restricted; (*d*) "impotence"; (*e*) a relatively high frequency of color responses; (*f*) an abnormal distribution of the various categories of color responses.

We have previously interpreted the presence of these signs as due to such behavior traits as meticulosity, fixation or inability to shift, forced responsiveness to stimuli, lack of affective-motor control. It may be noted that these are characteristics found in brain-injured adults and children alike (20). Two of the remaining signs of Piotrowski's were present in the brain-injured group but appeared also in the records of the endogenous groups. These signs are: (*a*) popular responses below normal;[18] (*b*) perseverations. Since these signs did not differentiate between the two groups, the probability is that they are general characteristics of the records of mentally deficient individuals rather than specific signs of an organic disturbance. Finally, there are four signs of Piotrowski's which did not appear in the records of our brain-injured group; these signs are: low percentage of plus forms, color-naming, "perplexity," and automatic phrases. Whether the presence of these signs in the brain-injured adult group, but not in the children, was due to the severity of injury or the higher age of the former cannot be decided. It already has been pointed out by Piotrowski that not all the signs may be expected to appear in patients under the age of 18, because age has a specific effect upon the incidence of these signs. A sign such as perplexity may be based on a mature viewpoint not developed in children (Klopfer and Kelley, 10, p. 335). On the other hand, the higher percentage of plus-form responses is possibly due to a lesser degree of intellectual deterioration of our children as compared with the brain-injured adults.

We will discuss below those characteristics of the brain-injured children not mentioned by Piotrowski. To these belong the greater number of whole, plus-form, piece-like and white-space responses, the interpretations in terms of humans and the *O*-minus responses. We have already stated that the greater number of *whole responses* in brain-injured children could be interpreted in two different ways: (*a*) as due to meticulosity and a trend toward perfection. The higher amount of *W* responses would then be due to specific behavior characteristics of a brain-injured organism. This explanation would agree with Harrower-Erickson's findings of a proportionately too high amount of whole responses in brain tumor cases; (*b*) as due to a higher intellectual status of the brain-injured in comparison with the endogenous group. In support of this interpretation one could point to statistics on normal children of the age range of our groups, showing a

[18]Even if one concedes a lower *P* per cent in children than in adults, the *P* per cent of both groups appears abnormally low. Compare Helen H. Davidson and B. Klopfer (3).

percentage of whole responses between 17 and 25 per cent (Davidson and Klopfer, 3, p. 40).

Similarly, the higher amount of *plus-form responses* in brain-injured children may be either due to the pathological trend of meticulosity or to the higher intellectual status of these children compared to the endogenous group. Here again, statistics compiled by Davidson and Klopfer show that the plus-form percentage of brain-injured children falls probably within the normal age range performance (70 to 80 per cent). In other words, the possibility remains that the difference in whole- and plus-form responses does not indicate abnormality in brain-injured children but intellectual inferiority in the non-brain-injured mentally deficient group.

Piece-like (oligophrenic) responses, not mentioned by Piotrowski, have been found to be very conspicuous with the brain-injured children, whereas endogenous children do not seem to deviate in these responses from the normal range computed by Davidson and Klopfer.[14] The underlying basic disturbance, that is, lack of synthesis, has been mentioned as a characteristic trend of brain-injured adults by Oberholzer, but not by Piotrowski. The number of *white space responses*, not found to be symptomatic for brain-injured adults, clearly distinguished the brain-injured from the endogenous group. Again, an inspection of Davidson and Klopfer's data seem to confirm our data that the number of S responses of our brain-injured children was relatively high with respect to records of normal children of comparable ages. The same can be said about *Human responses.* Percentages as high as 20.7 (average for the brain-injured group) were never recorded in Davidson and Klopfer's tables for normal children. One of the outstanding characteristics of our brain-injured group, the high amount of *original (particularly O—) responses*, has not been recorded by Piotrowski. However, Oberholzer mentioned this type of response as being especially conspicuous in the records of his organic patients.

To sum up: Many of the characteristics distinguishing the group of organic children from the endogenous group have been found to be part of the records of brain-injured adults. These signs are: restriction of total responses, lengthened average time, M-responses, "Impotence," color responses, abnormal distribution of CF and C with respect to FC responses, and O-minus responses. Signs such as a higher amount of Whole and Plus-form responses present in the brain-injured group were not found to be

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[14]Normals gave approximately 2.8 per cent in the 12 to 16 age group against 5.5 per cent given by our brain-injured, and 1.7 per cent by the endogenous group.

characteristic for brain-injured adults.[16] Even with our groups, these signs, though distinguishing between the brain-injured and endogenous individuals, do not differentiate between brain-injured and normal children of the same chronological age. The three remaining, definitely abnormal signs, not mentioned in the studies on adult individuals are the oligophrenic, the *S*—, and the Human responses. The possibility remains that the presence of these signs depends on the occurrence of brain-injury during early stages of brain development.

All together, the comparison of the records of our brain-injured group with that of adults adds weight to the already considerable evidence of specific psychologic differences between the two types of mentally deficient children.

[16]Only Harrower-Erickson noticed a relatively high amount of whole responses in her patients' records.

V. SUMMARY: THE BEHAVIOR CHARACTERISTICS OF BRAIN-INJURED CHILDREN AS CONVEYED BY THEIR RESPONSES TO THE INK-BLOTS

The main purpose of this study was to analyze the perceptual and conceptual behavior of brain-injured and non-brain-injured subnormal children of comparable mental ages by means of the Rorschach technique.

A number of significant differences between the two groups have been found. These differences were interpreted in the light of results from (*a*) previous experiments with two similarly formed groups of children, (*b*) previous work on the Rorschach test with brain-injured adults, (*c*) general studies on the Rorschach test.

This analysis appears to justify the conclusion that the brain-injured differs from the non-brain-injured mentally subnormal group, in certain general traits enumerated below.

1. *Lack of integration of elements into more comprehensive configuration* has been previously shown to characterize sensori-motor performance of brain-injured children. Indications of disintegrative tendencies are the predominance of piece-like (oligophrenic) detail responses (*Do, Hd, Ad*).

2. *Forced responsiveness to sensory stimulation or lack of sensory control* is a well-known symptom of a brain-injured organism. Reactions to perceptually conspicuous areas such as white parts may be considered a result of this behavior. Reversals in the normal relationship of figure and background appeared in the ink-blot situation as a tendency of brain-injured children to react to the white spaces.

3. *Lack of affective-motor control* demonstrating itself clinically in hyperactivity, outbursts, etc., was evidenced in the Rorschach test by abnormally strong reaction to color, and by a relatively small number of movement responses.

4. *Lack of associational control* conveyed itself on the Rorschach test—as on the previous conceptual tests—in the tendency of the brain-injured children toward strange and fantastic interpretations (*O—* responses).

5. *Meticulous behavior* has been observed on all previous tests with many of the brain-injured children. Meticulosity of these children was evident by their attitude toward the ink-blot test: they took the task more literally than the other group, were often apologetic for an interpretation, if it did not completely fit the object. This meticulosity was probably partially responsible for their higher number of whole and plus form responses.

6. *Pathological rigidity: i.e., inability to shift, perseverations,* are known to be symptomatic of brain-injury. Since rigidity, however, is not

only a pathological trait but is characteristic of mental deficiency in general, it is not surprising that quantitative differences between the two groups have not been found. The form percentage was equally high with both types, indicating a high degree of rigidity. Similarly, perseverative tendencies in general, were equally frequent with the two groups. On the other hand, there were some indications in the records of the brain-injured children of a pathological form of rigidity. In view of earlier evidence, it seems reasonable to interpret the smaller total number of responses of these children as being at least partly caused by the inflexibility in the shift from one interpretation of the ink-blot to another one. Furthermore, whereas the repetitive responses of the endogenous children were exclusively in the nature of a superficial stereotypy, the (very few) occurrences of perseverations caused by a deep-set inflexible mental attitude appeared only in the records of brain-injured children.

It seems that characteristic *clusters of behavior traits* of brain-injured children can be deduced from this analysis. Since these trait groups are seemingly contradictory to one another, one gets a rather paradoxical picture of the personality make-up of these children. On the one side, one finds disinhibition in the sensory, and motor-affective, associational areas, and on the other, an overcritical, meticulous attitude. There are signs of disintegration, such as piece-like perception, but then an urge toward perfection and completeness is noticeable. Excessive fluidity of associational processes frequently is present in the same child together with a high degree of rigidity, an inability to shift and perseverative tendencies.

Now, such paradoxical behavior patterns of brain-injured individuals have been observed previously in adults (Goldstein, 4) as well as in children (Strauss and Werner, 19). The paradox appears to be a fundamental sign of neuropsychological unbalance of an organism whose integrative powers have been disturbed due to brain-injury. Such opposing features may be the expression of one and the same primary disturbance. For instance, lack of control may either disable the individual to shift from one activity to another (rigidity) or may disable him to restrain the flow of association (excessive fluidity). On the other hand, contradictory phenomena may be of a compensatory relationship. Thus, the suggestion has been made (Goldstein) that extreme orderliness or pedantry is the brain-injured child's compensatory reaction to his disinhibitory trends,—a protective mechanism against a chaotic existence.

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